Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

DECEMBER, 1948

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ECHNOLOGY DEPARTME

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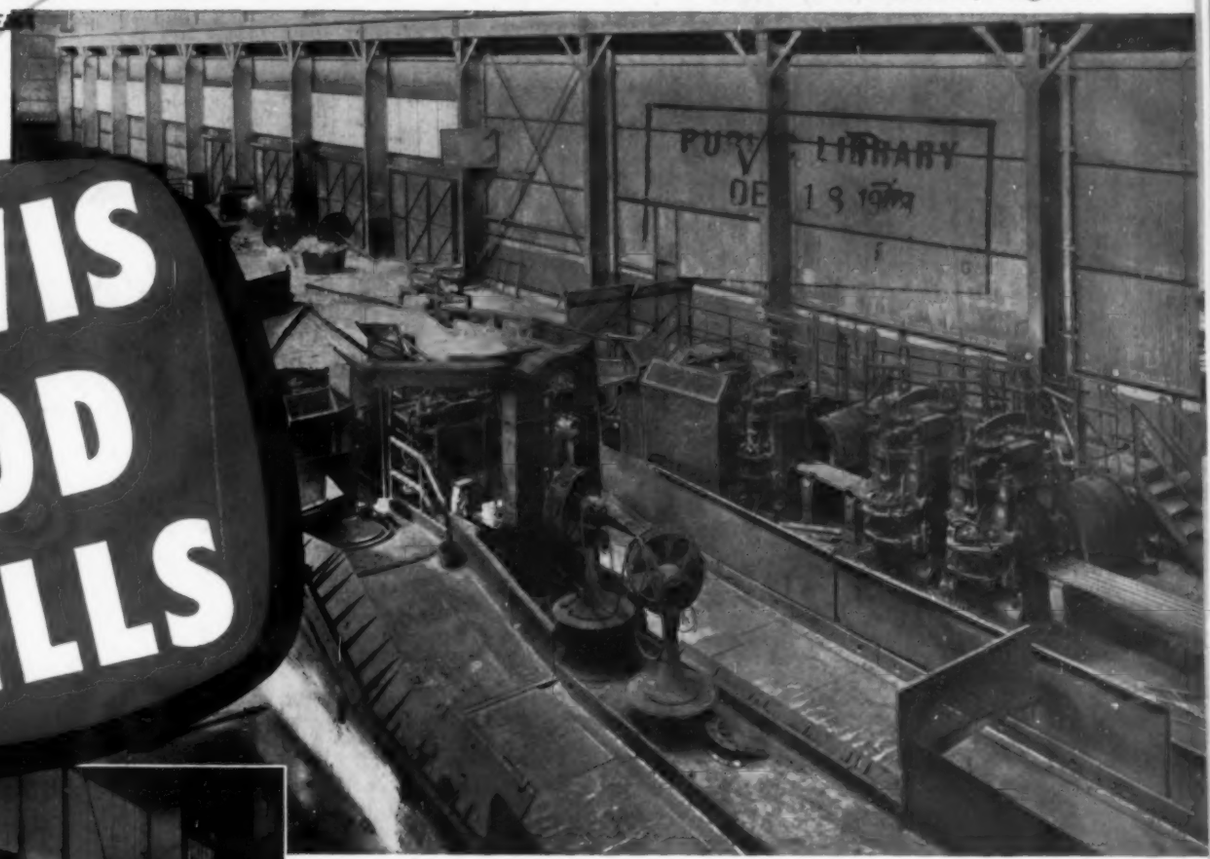
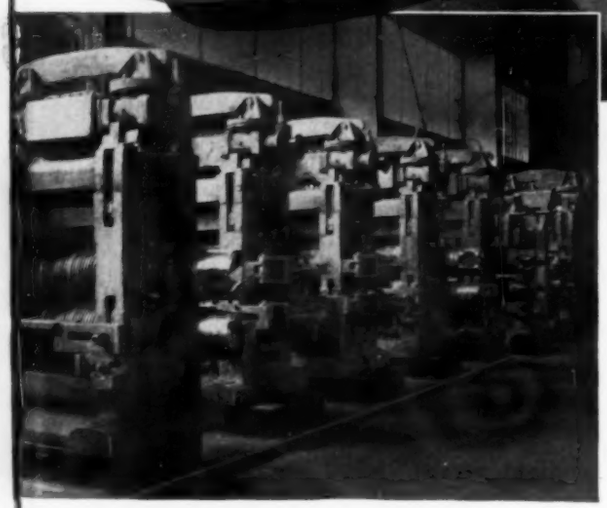


LEWIS ROD MILLS



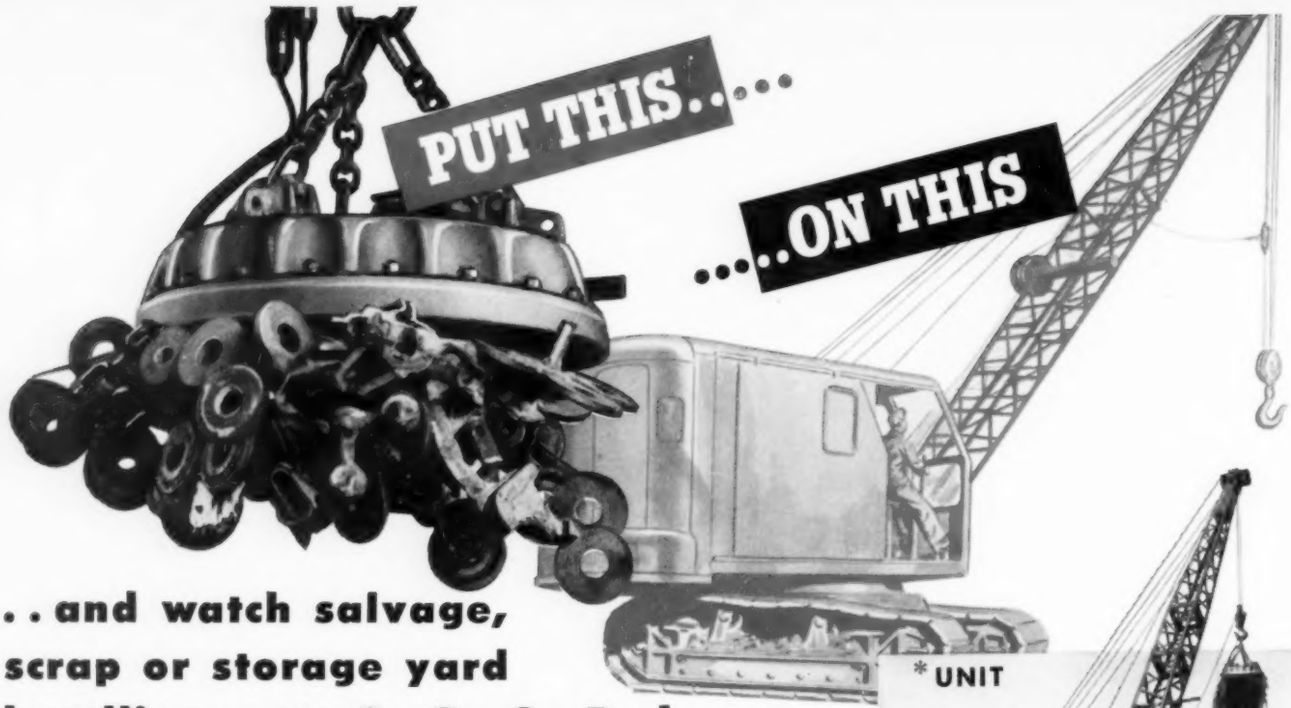
★ HIGH TONNAGE MILLS OF GREAT FLEXIBILITY

In both continuous and semi-continuous types, Lewis Rod Mills are designed to handle a diversified output of highly specialized alloy steels . . . Lewis engineers welcome the opportunity to develop new rolling machinery for your particular requirements.

MANUFACTURERS OF ROLLS AND ROLLING MILL MACHINERY FOR THE IRON, STEEL AND NON-FERROUS INDUSTRIES

LEWIS FOUNDRY & MACHINE

DIVISION OF BLAW-KNOX COMPANY, PITTSBURGH, PA.



..and watch salvage, scrap or storage yard handling costs D-R-O-P-!

You can mobile-mount a Cutler-Hammer BIG-LIFT fast-acting magnet on anything that moves, has a boom and a power supply. And this mobile, go-anywhere unit speeds the movement and classification of iron and steel scrap, turnings, cuttings, pig iron, axles . . . bagged, boxed, bundled or loose ferrous parts in your yards . . . cutting costs as it goes. It *goes* . . . where overhead and locomotive cranes cannot reach.

C-H Supermagnets give maximum load per lift, maximum day-long performance, maximum working life because of many structural superiorities . . . manganese bottom plate, dynamo steel body, vacuum impregnated coil, watertight terminal box, etc. Get your Cutler-Hammer Supermagnet direct or already mounted from crane or truck manufacturer. Many operators are doing it . . . to their profit. CUTLER-HAMMER, Inc., 1257 St. Paul Ave., Milwaukee 1, Wisconsin.

CUTLER-HAMMER
SUPERMAGNETS
C-H

*Mounted on**

*UNIT

Unit Crane & Shovel Corp., Milwaukee, Wis., crawler crane

*KRANE KAR

Silent Hoist & Crane Co., Brooklyn, N. Y., "Krane Kar"

*MICHIGAN

Michigan Power Shovel Co., Benton Harbor, Mich., truck mounted crane

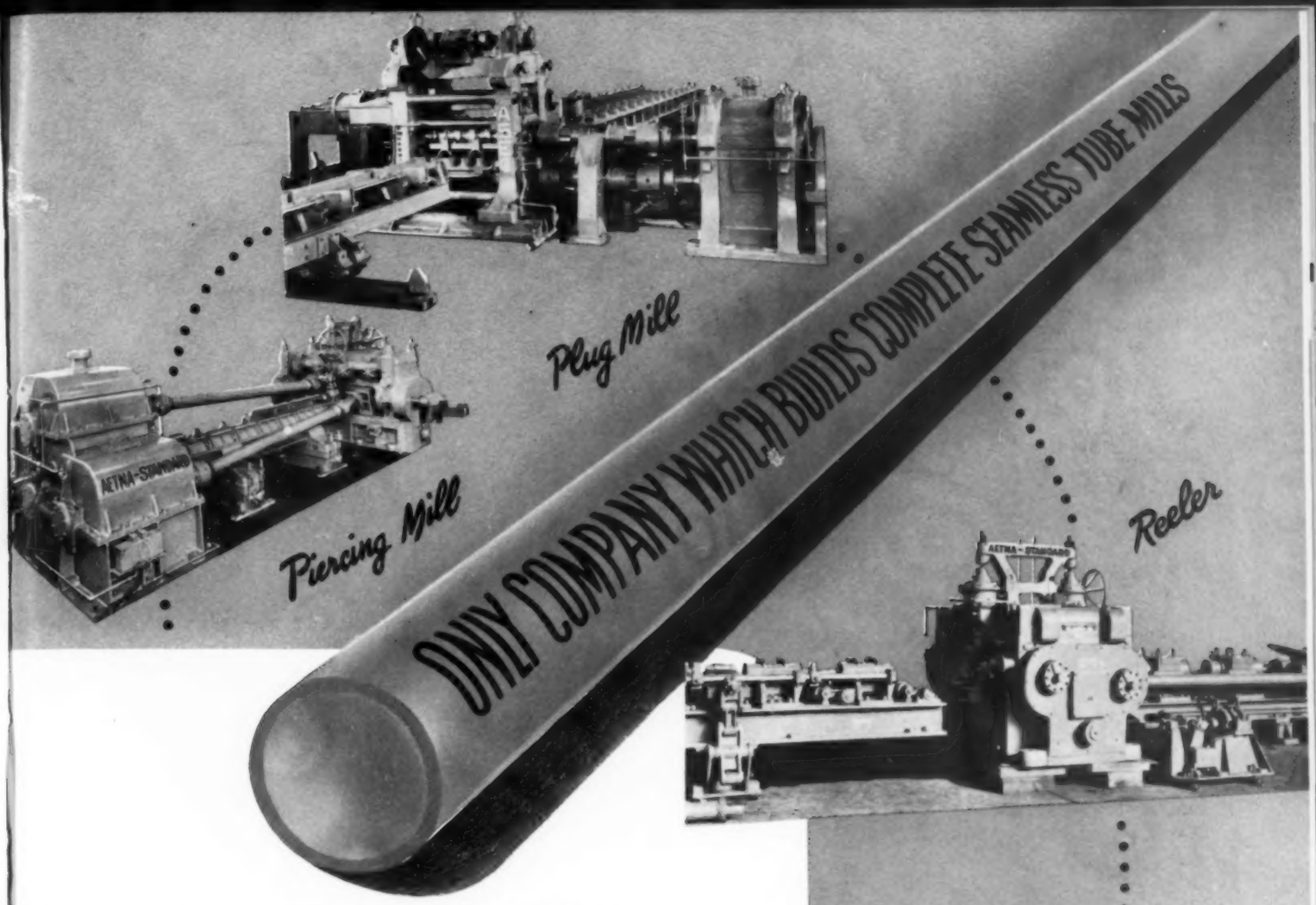
*BAY CITY

10 ton crane, Bay City Shovels, Inc. Bay City, Mich., in scrap yard

*HYDRO-CRANE

Mobile crane made by Hydro-Crane Division of Bucyrus-Erie Co., Milwaukee, Wis.

IRON AND STEEL ENGINEER, published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress March 3, 1879. $7.50 per year in United States, $8.25 Canada, $10.00 foreign countries. Volume 25, No. 12.



● To you who may be contemplating a capital expenditure for tube or pipe mill equipment, Aetna-Standard's supremacy in seamless tube mills is important. Only Aetna-Standard alone has all the facts, figures and data you need to evaluate this major expenditure in the cold light of costs.

As the world's foremost seamless tube mill builder, Aetna-Standard has designed and constructed most of the seamless tube mills in this country and foreign lands.

In fact, only Aetna-Standard, of all companies, has the facilities and experience to engineer, build and install a *complete* seamless tube mill.

THE AETNA-STANDARD ENGINEERING COMPANY
YOUNGSTOWN, OHIO

ASSOCIATED COMPANIES:

HEAD, WRIGHTSON & COMPANY, LTD., THORNABY-ON-TEES, ENGLAND
AETNA-STANDARD ENGINEERING COMPANY, LTD., TORONTO, ONTARIO, CANADA

The unseen qualities that "make" a roll

The inherent strength and durability of National Rolls are due to careful attention paid at National to every step of production.

Experienced personnel in the fully equipped National laboratory maintains constant metallurgical supervision over all manufacturing operations.

In the foundry and roll shop, skilled craftsmen exercise exacting care in pouring and machining to assure flawless roll castings and precision finished roll surfaces.

This constant behind-the-scenes control of quality assures you long, dependable service from every National Roll you buy.

National Rolls

THE NATIONAL ROLL & FOUNDRY CO.
AVONMORE, PENNSYLVANIA

Specialists in **IRON** *and* **ALLOY IRON ROLLS**

Gear Down Maintenance Costs

Keep your enclosed gears fully protected with Texaco Meropa Lubricants.

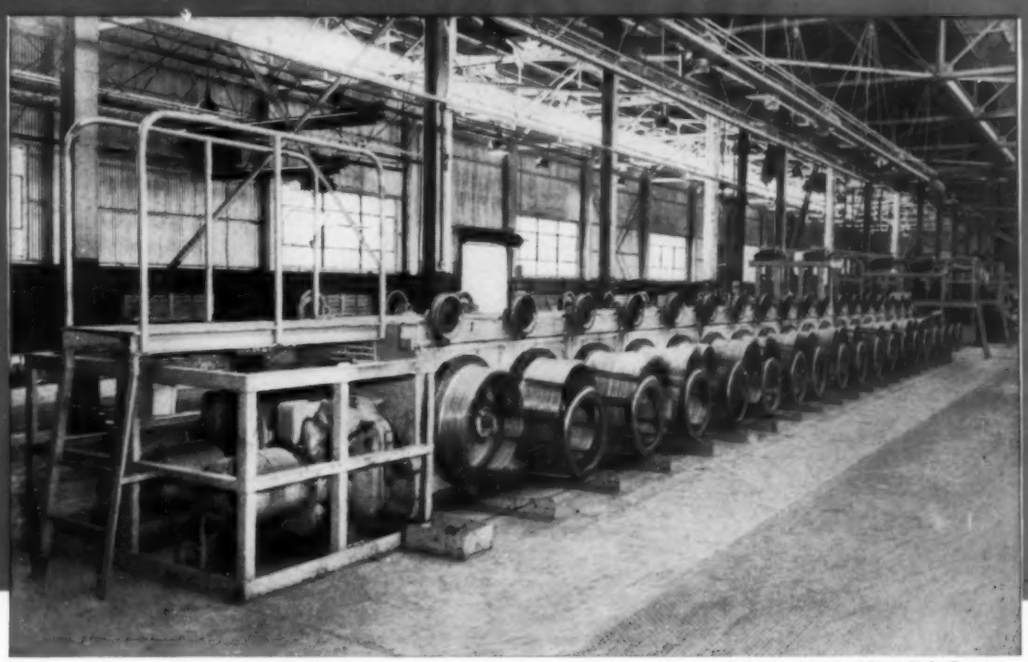


Photo courtesy of Link-Belt Company.

Steel mill take-up, utilizing 36 worm gear speed reducers and (fenced in foreground) several P.I.V. variable speed changers.

PUT *Texaco Meropa Lubricants* in your reduction gear drives and you've got full protection for gears and bearings. These heavy-duty lubricants can shoulder the heaviest loads . . . and their tough films cling to the gear teeth for perfect follow-through. There's never a let-up in protection.

In addition, *Texaco Meropa Lubricants* keep fit for long service. They fight oxidation and thickening . . . do not foam . . . do not separate in service, storage, or centrifuging. They protect against bearing corrosion. Use *Texaco Meropa Lubricants* in all heavy-duty enclosed gears.

In circulating systems for oil film roll necks, use *Texaco Regal Oils*. These heavy turbine-grade oils stand up under high temperatures . . . carry heavy loads easily . . . resist oxidation, emulsification and sludging, thus keeping the system clean for full protection and lower maintenance costs.

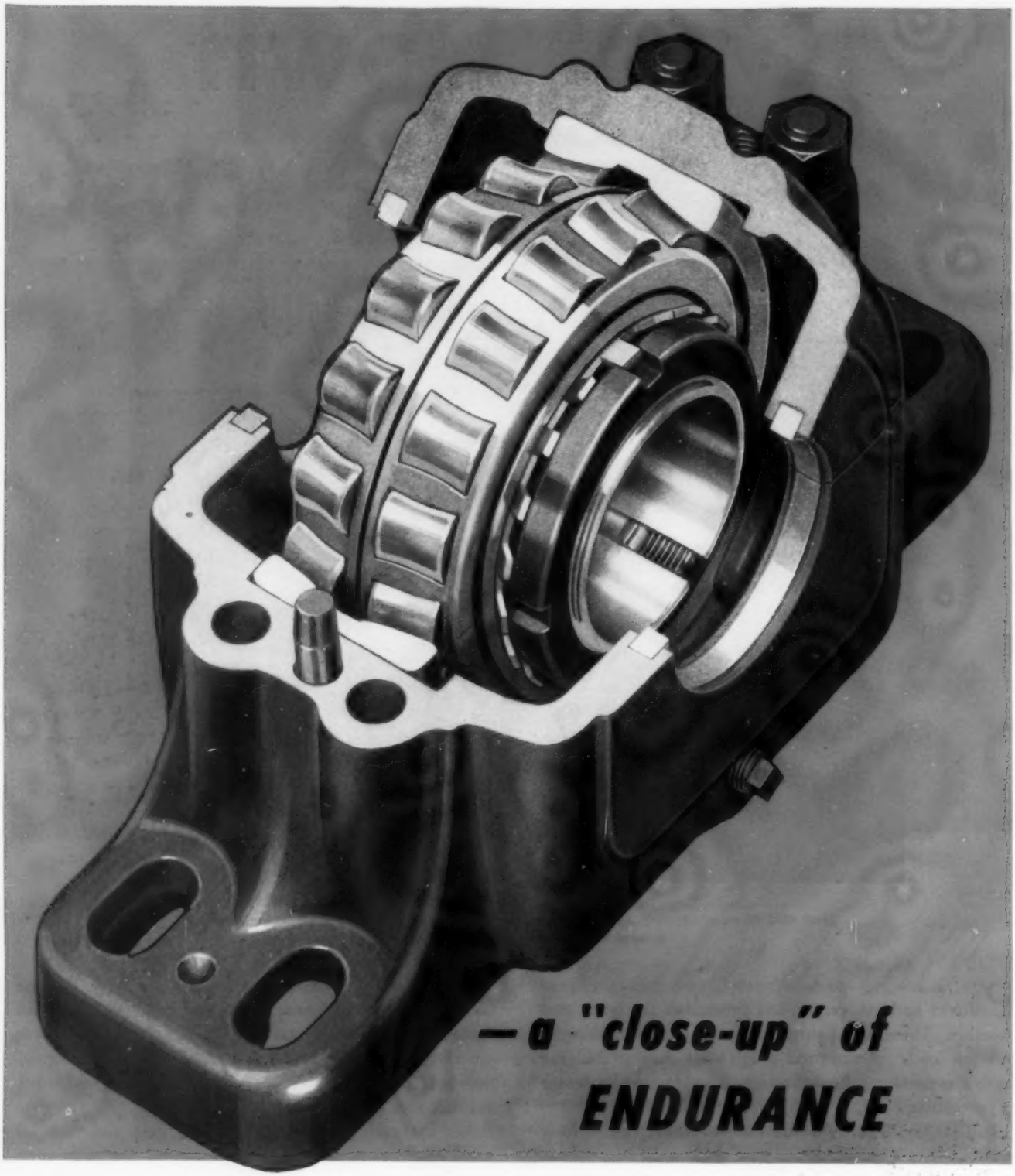
Let a Texaco Lubrication Engineer help you with *all* your lubrication. Just call the nearest of the more than 2300 Texaco Wholesale Distributing Plants in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.

TEXACO

TEXACO Meropa Lubricants

FOR STEEL MILL GEAR DRIVES

Tune in . . . TEXACO STAR THEATRE presents MILTON BERLE every Wednesday night. METROPOLITAN OPERA broadcasts every Saturday afternoon.



Good bearing design calls for combination of the ultimate in precision with ruggedness of construction. Link-Belt designers, who know the problems of power transmission best, have created a line of ball and roller bearings which will serve you well and longer. May we send catalogs?

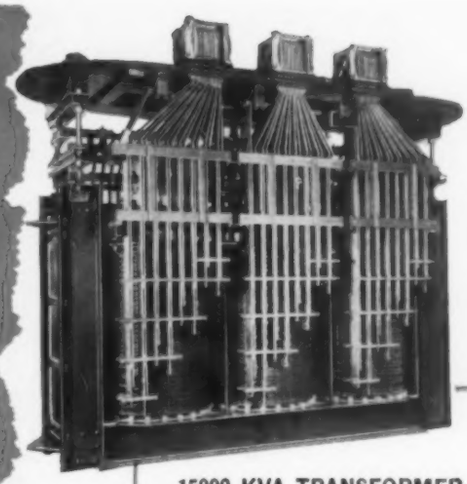
11,287

LINK-BELT COMPANY Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities.

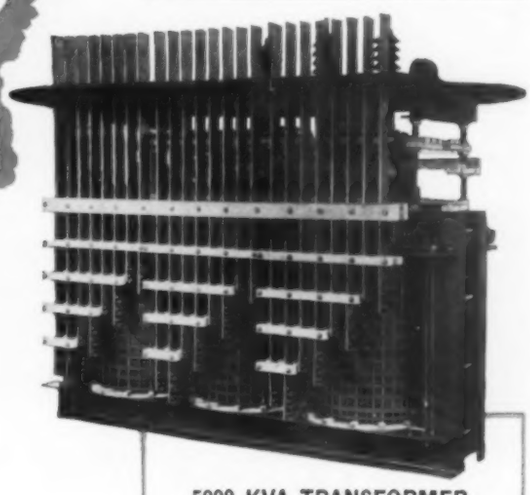
LINK-BELT *Ball and Roller BEARINGS*

Over
1 MILLION KVA
of Pennsylvania Furnace Transformers
Now in Service!

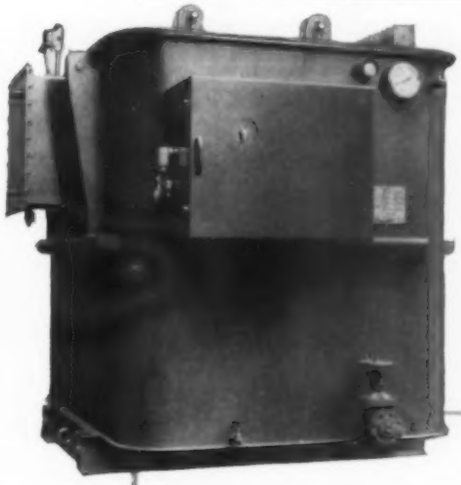
YES, Pennsylvania Furnace Transformers, totaling over 1 Million KVA, are supplying power to hundreds of electric furnaces. The successful operation of these transformers has given Pennsylvania Transformer Company a noted reputation in the Furnace Transformer field. For over 35 years, Pennsylvania Engineers have closely followed the development of Electric Furnaces. They fully understand the problems of Electric Furnaces and their relation to Furnace Transformers.



15000 KVA TRANSFORMER
for operating a 75-Ton Furnace

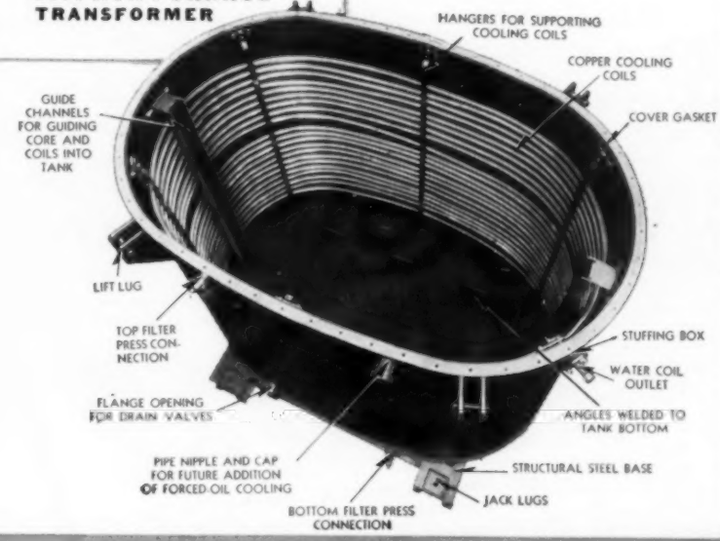


5000 KVA TRANSFORMER
for operating a 15-Ton Furnace



7500 KVA TRANSFORMER
for operating a 30-Ton Furnace

TANK INTERIOR OF 2500 KVA FURNACE TRANSFORMER


HANGERS FOR SUPPORTING COOLING COILS
COPPER COOLING COILS
COVER GASKET
GUIDE CHANNELS FOR GUIDING CORE AND COILS INTO TANK
LIFT LUG
TOP FILTER PRESS CONNECTION
STUFFING BOX
WATER COIL OUTLET
FLANGE OPENING FOR DRAIN VALVES
ANGLES WELDED TO TANK BOTTOM
PIPE NIPPLE AND CAP FOR FUTURE ADDITION OF FORCED-OIL COOLING
STRUCTURAL STEEL BASE
JACK LUGS
BOTTOM FILTER PRESS CONNECTION

Pennsylvania TRANSFORMER COMPANY

Pennsylvania TRANSFORMERS

Furnace Transformer Experts

PITTSBURGH 12, PENNSYLVANIA

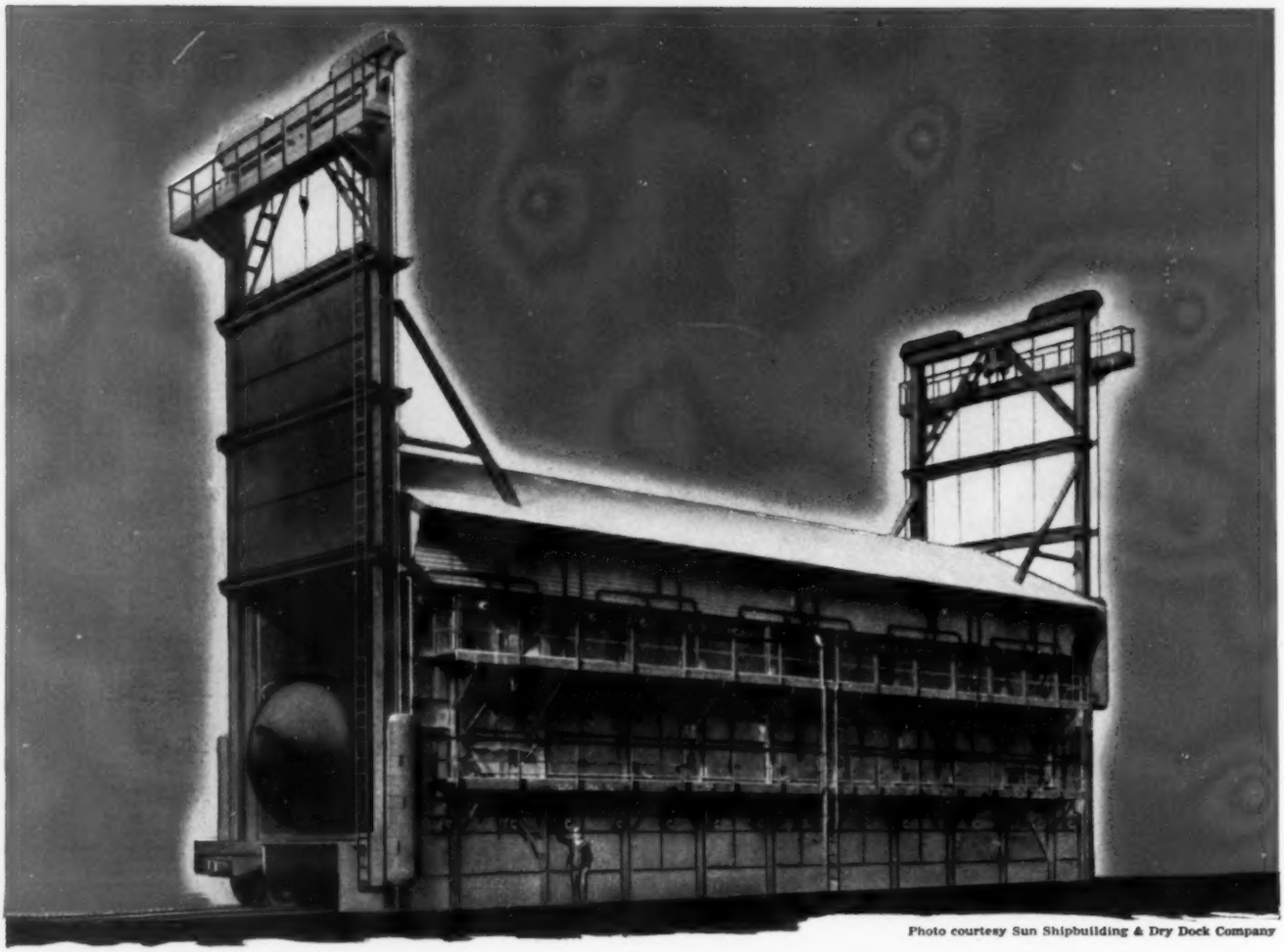


Photo courtesy Sun Shipbuilding & Dry Dock Company

The furnace that PAID FOR ITSELF MANY TIMES OVER

Still lined with its original B&W Insulating Firebrick after 15 years of continuous normalizing and stress-relieving service, this furnace is giving exceptional performance. Despite the added strain of the rigorous war years, the 80,000 B&W IFB used to line sides, ends and arch have required no appreciable maintenance!

It is no wonder the operators can report:
"This furnace has paid for itself many times over."

For furnace performance that assures highest production at lowest cost, even after years of grueling service, you can always count on lightweight B&W Insulating Firebrick. Your local B&W Refractories Engineer will be glad to help you select economical B&W Refractories for your furnaces.

R-310

B&W REFRACTORIES PRODUCTS

B&W 80 FIREBRICK • B&W JUNIOR FIREBRICK
B&W 80 GLASS TANK BLOCKS • B&W INSULATING FIREBRICK
B&W REFRACTORY CASTABLES, PLASTICS AND MORTARS

•

OTHER B&W PRODUCTS

Stationary & Marine Boilers and Component Equipment
Chemical Recovery Units . . . Seamless & Welded Tubes . . . Pulverizers
Fuel Burning Equipment . . . Pressure Vessels . . . Alloy Castings

BABCOCK & WILCOX

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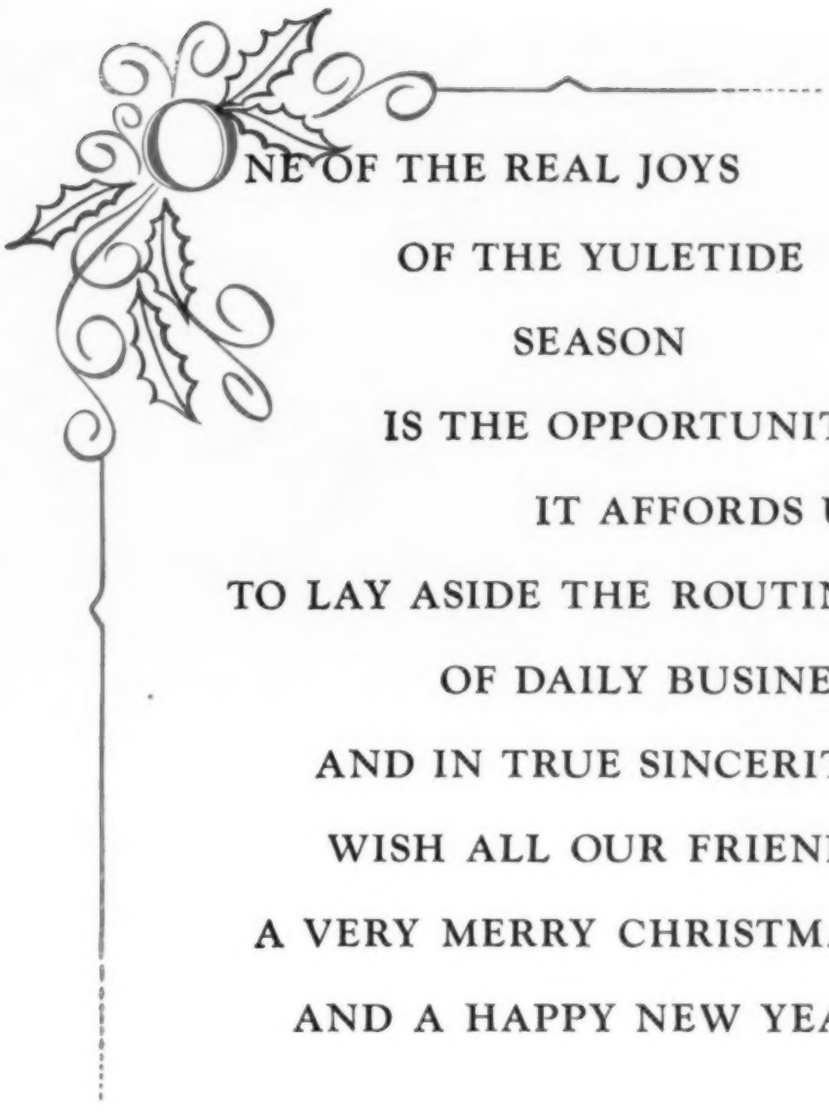
REFRACTORIES DIVISION
GENERAL OFFICES: 85 LIBERTY ST., NEW YORK 6, N.Y.
WORKS: AUGUSTA, GA.

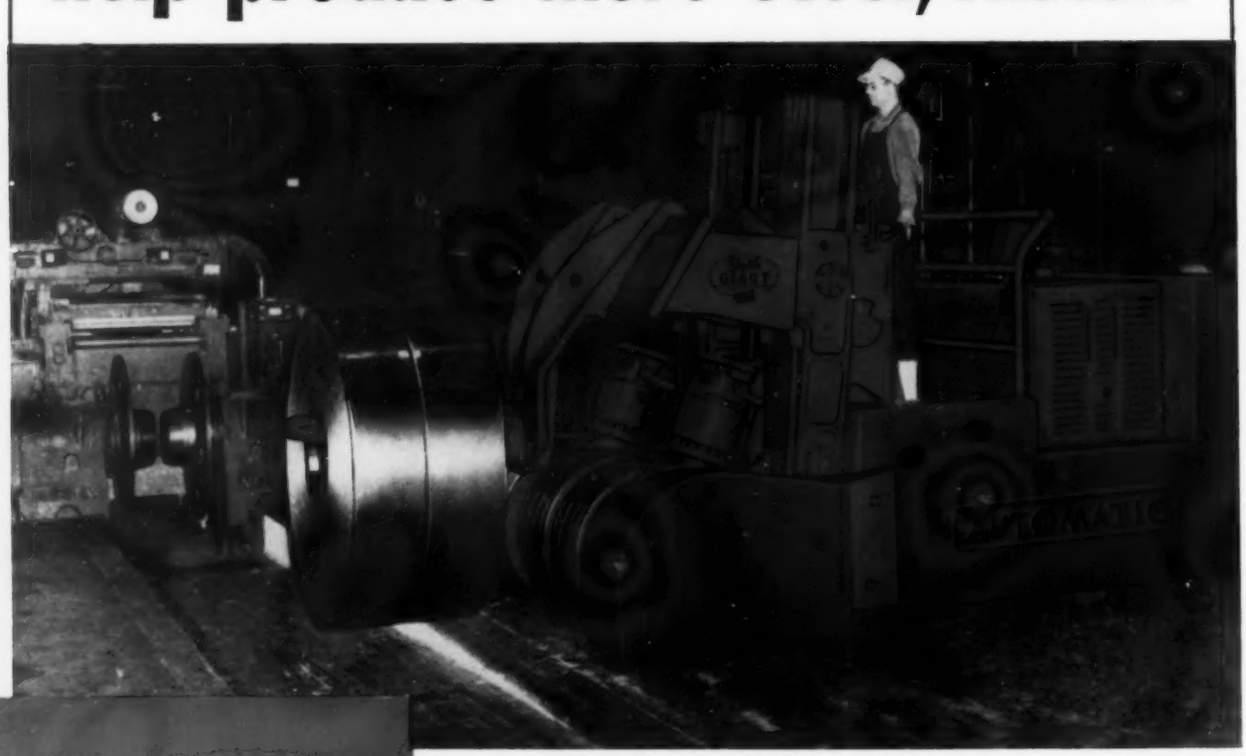


ONE OF THE REAL JOYS
OF THE YULETIDE
SEASON
IS THE OPPORTUNITY
IT AFFORDS US
TO LAY ASIDE THE ROUTINE
OF DAILY BUSINESS
AND IN TRUE SINCERITY
WISH ALL OUR FRIENDS
A VERY MERRY CHRISTMAS
AND A HAPPY NEW YEAR

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

How Skylift GIANTS help produce more steel, faster!



ABILITY TO HANDLE 25,000 POUND STEEL COILS GIVES PRODUCTION TERRIFIC BOOST AT GRANITE CITY STEEL CO. NEW COLD STRIP MILL

In the effort to boost steel output, part of the solution has been found in the design of faster strip mills, capable of processing larger quantities of metal in a single operation and at increased speed. But, the new mills themselves added to the problem. How were they to be fed with the huge coils of steel they were capable of handling?

Granite City Steel Company, Granite City, Illinois, found the answer in the Skylift GIANT!

Operating at full speed, its new cold strip mill will produce enough steel in a 24-hour period to stretch from New York to St. Louis. Literally making this possible, are the Skylift GIANTS.

Huge coils weighing from 15 to 25,000 pounds are moved by Skylift GIANTS to the tandem cold strip mill where the hot rolled coil is reduced to cold strip. Again Skylift GIANTS move the coils to the electrolytic cleaner for removal of rolling oils.

And through every process until the tinplate is ready for shipment, Automatic's mighty giants of electric power handle coils large enough to meet every requirement of speed in delivering to and discharging coils from the mill. Result is 25% more coils processed at capacity operation.

Skylift GIANTS are specially engineered to handle all sizes, all weights of coils.

Four front drive wheels provide as much as 80 inches of rubber. Pivoted drive axles give constant 4-wheel traction regardless of floor conditions—controlled caster type trail axle, center-pivoted, compensate for uneven floor surfaces. Nearly 20% lighter in proportion to load capacity than other heavy-duty fork and ram tractors —Skylift GIANTS are the only heavy-duty trucks with HIGH PRESSURE HYDRAULIC LIFT that eliminate chains and sprockets.

Mail coupon for facts about how Skylift GIANTS offer *your business* amazing production and handling savings.

3rd ★★★★ NATIONAL MATERIALS HANDLING EXPOSITION PHILADELPHIA CONVENTION HALL JAN. 10-14, 1949

Manufacturers of the Famous Transporters, Transtackers and Skylift Electric Trucks

Skylift GIANT

A PRODUCT OF AUTOMATIC

Lighten Life's Loads

AUTOMATIC TRANSPORTATION COMPANY

DIV. OF THE YALE & TOWNE MFG. CO.

47 W. 87th St., Dept. X-8, Chicago 20, Ill.

☐ Send details on Automatic's Skylift GIANTS Fork and Ram Trucks.

☐ Have an ATCO Specialist make a free survey of our material handling costs.

Company Name.....

.....

By.....

.....

Street Address.....

City.....

Zone.....*State*.....

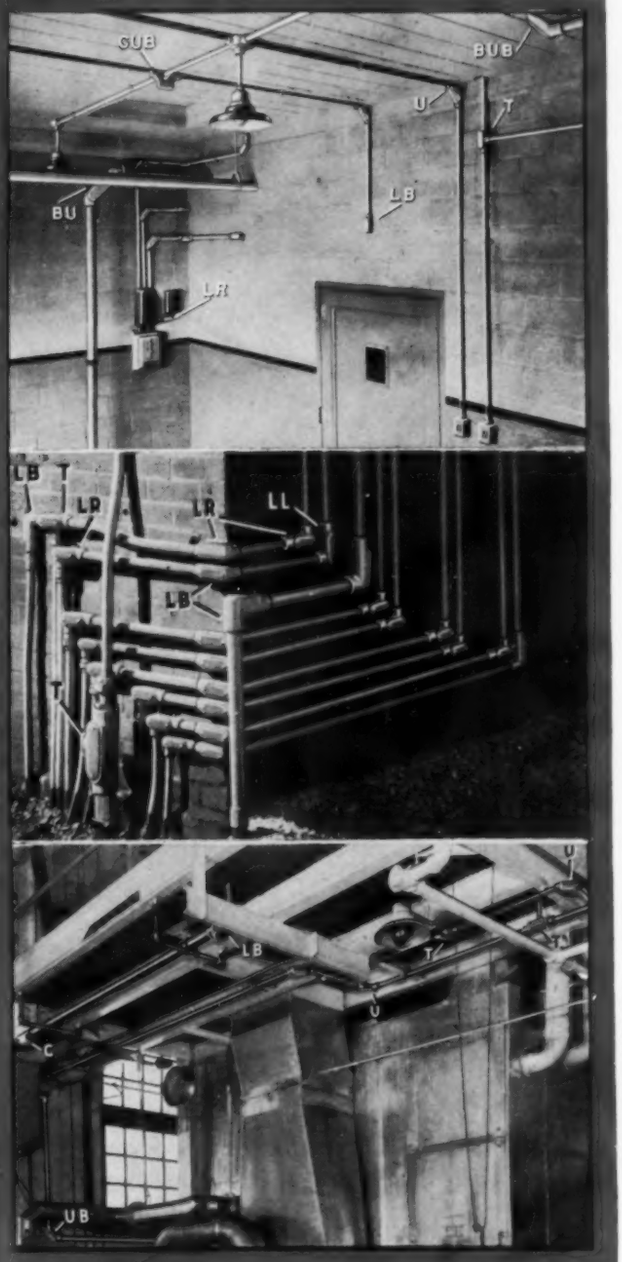
Installing electrical conduit?

It's much **easier** with

Obround CONDULETS*

because they are so handy and there are

49 different types



A wide variety of interchangeable covers and wiring devices with Crouse-Hinds' exclusive Wedgenut Fastener; sizes to fit ½ to 6-inch electrical conduit.

A Nationwide Distribution Through Electrical Wholesalers

* *CONDULET is a coined word registered in the U. S. Patent Office. It designates a product made only by the Crouse-Hinds Company.*

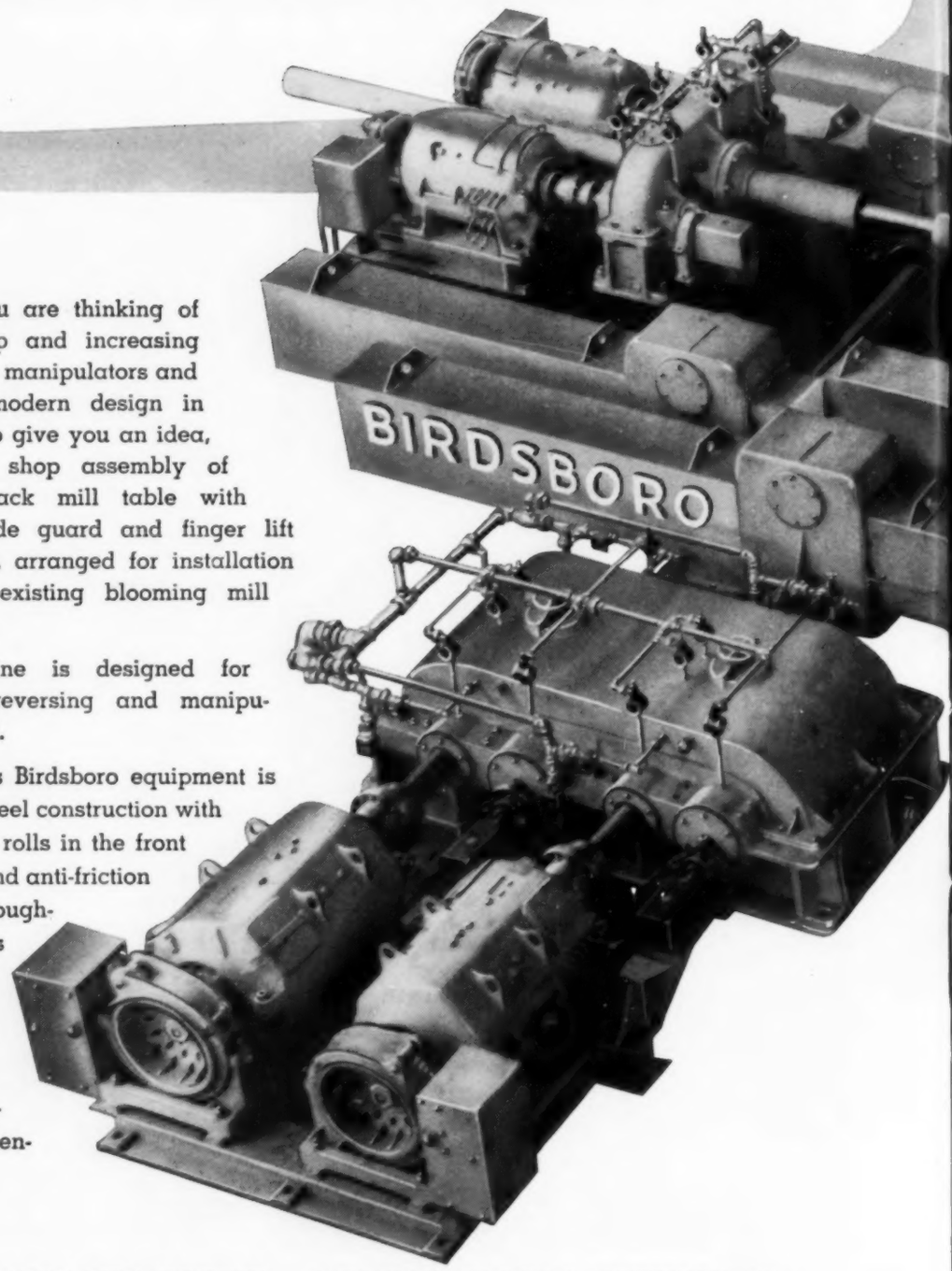
The complete Obround Series, together with 15,000 other items for the electrician, is listed in Crouse-Hinds Condulet Catalog.

CROUSE-HINDS COMPANY
Syracuse 1, N. Y.

Offices: Birmingham — Boston — Buffalo — Chicago — Cincinnati — Cleveland — Dallas — Denver — Detroit — Houston — Indianapolis — Kansas City
Los Angeles — Milwaukee — Minneapolis — New York — Philadelphia — Pittsburgh — Portland, Ore. — San Francisco — Seattle
St. Louis — Washington. *Resident Representatives:* Albany — Atlanta — Baltimore — Charlotte — New Orleans — Richmond, Va.
CROUSE-HINDS COMPANY OF CANADA, LTD., *Main Office and Plant:* TORONTO, ONT.

CONDULETS · TRAFFIC SIGNALS · AIRPORT LIGHTING · FLOODLIGHTS

speed up ROLLING MILL OPERATION



• When you are thinking of speeding up and increasing output, keep manipulators and tables of modern design in mind. Just to give you an idea, here is a shop assembly of front or back mill table with movable side guard and finger lift manipulator, arranged for installation with your existing blooming mill equipment.

This machine is designed for maximum reversing and manipulating speed.

Because this Birdsboro equipment is built of all-steel construction with forged steel rolls in the front of the mill and anti-friction bearings throughout, it stands up under the most severe service with minimum maintenance.

BIRDSBORO STEEL FOUNDRY and MACHINE COMPANY, BIRDSBORO, PA.
OFFICES IN: BIRDSBORO, PA. and PITTSBURGH, PA.

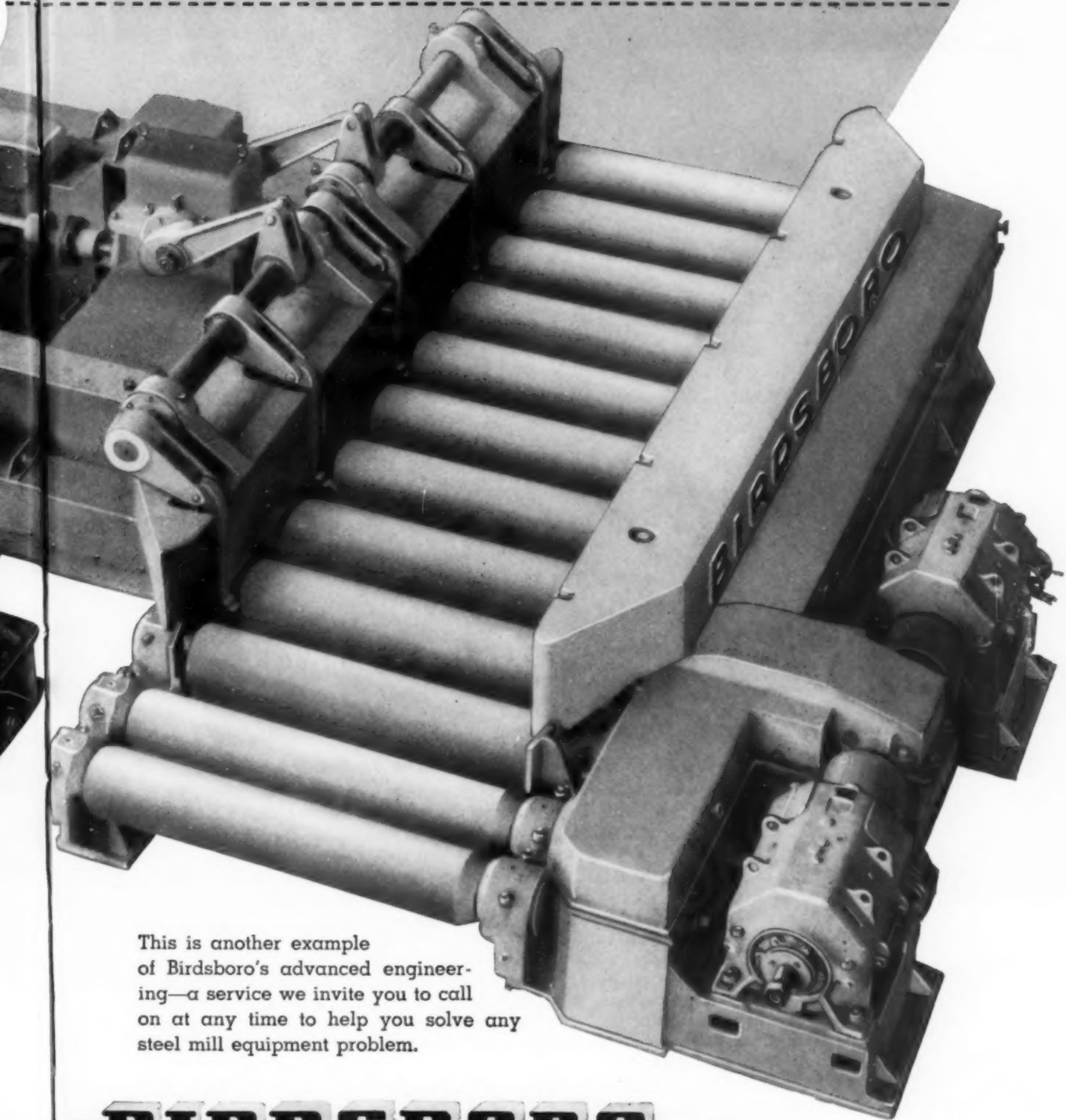
REPRESENTATIVES AT:

332 South Michigan Ave., Chicago 4, Ill.

507 Terminal Tower Bldg., Cleveland 13, Ohio

with this modern

BIRDSBORO MANIPULATOR & TABLE



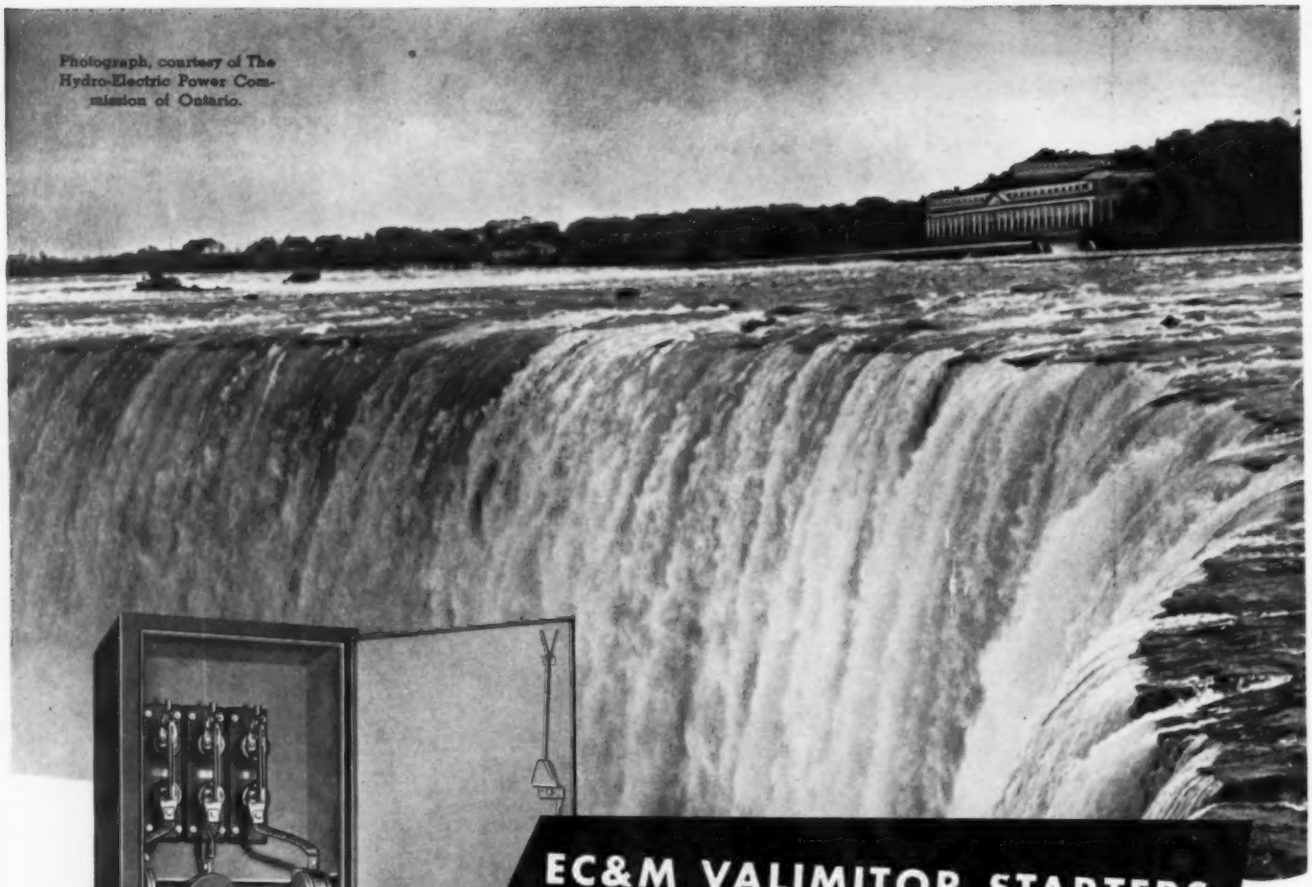
This is another example of Birdsboro's advanced engineering—a service we invite you to call on at any time to help you solve any steel mill equipment problem.

BIRDSBORO

STEEL MILL EQUIPMENT

ME-2-48

DESIGNERS and BUILDERS OF: STEEL MILL EQUIPMENT • HYDRAULIC PRESSES • ROLLS
SPECIAL MACHINERY • STEEL CASTINGS • CRUSHING MACHINERY



Photograph, courtesy of The Hydro-Electric Power Commission of Ontario.

EC&M VALIMITOR STARTERS can be mounted Smack up to NIAGARA FALLS

VALIMITOR Starters are built for 2300 volt motors up to 600 hp. on 60-cycle systems; up to 300 hp. on 25-cycle service. Above 2300 volts and up to 4600 volts, starters are designed for motors up to 600 hp. at 60 cycles and up to 250 hp. for 25-cycle motors.

Complete Protection No Matter How Great the Available KVA.

No need to worry, now or at some future time, about the available KVA to which your 2300-4600 volt motor drives may be subjected. EC&M VALIMITOR Starters give *permanent* protection — *nothing* to replace—*no change* later on, even if present capacity is increased.

As the name VALIMITOR (volt-ampere-limitor) implies, these Starters are designed to limit the maximum possible fault current to 25,000 KVA (steady state), even when connected to a system having infinite available KVA. The well-known Type ZHS Magnetic Contactor, having 50,000 KVA interrupting capacity, is more than adequate for the interruption of such faults, including any initial, short-time transients. Because of inherent impedances of any system, the actual possible fault currents will be further restricted. Irrespective of this, however, the electro-magnetic forces and thermal effects under a fault condition are limited by VALIMITOR Starters to safe values.

EC&M VALIMITOR Starters can be applied without analyzing the system for maximum available KVA at the point of application. Simply tell us the HP, voltage, phase and frequency of your motors, and whether squirrel-cage, wound-rotor or synchronous type.

THE ELECTRIC CONTROLLER & MFG. CO.

2698 East 79th Street — Cleveland 4, Ohio

That depends on production schedules . . . but today, when demand is up . . . you can't afford to lose valuable production time.

Wagner type CP totally-enclosed, fan-cooled motors are designed for a particular purpose—to operate efficiently in atmospheres filled with dust, fumes, moisture and other agents that quickly ruin open type motors.

Steel mill operators have found from experience that it pays to use Wagner CP Motors—they stay on the job, requiring no maintenance other than periodic lubrication, in spite of the destructive elements in the surrounding atmosphere. You will find CP motors a lasting investment in continuous, troublefree motor performance.

More than fifty-five years of experience stands behind every motor bearing the Wagner name. Nationwide service facilities are available to users of Wagner Motors.

Call any of our twenty-nine branch offices, located in principal cities and manned by trained field engineers, for advice on all of your motor problems. Bulletins on the complete line of Wagner Motors will be sent upon request.

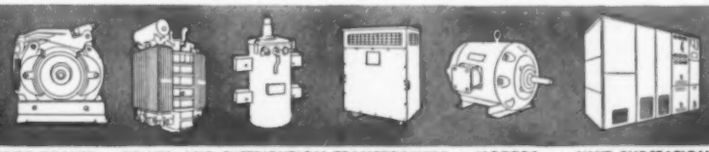
Wagner
type CP **Motors**

This totally-enclosed, fan-cooled polyphase motor has all vital parts sealed in an inner frame.

Wagner Electric Corporation
6483 PLYMOUTH AVE., ST. LOUIS 14, MO., U. S. A.

Consult Wagner Engineers on all Electric Motor Problems

Wagner Electric Corporation
EST. WE 1891



M48-20

BRIDGE BRAKES • POWER AND DISTRIBUTION TRANSFORMERS • MOTORS • UNIT SUBSTATIONS
ELECTRICAL AND AUTOMOTIVE PRODUCTS

Great Care and Long Experience Go into the Pouring of Every Phoenix Roll.

Pittsburgh Rolls alloy iron work rolls and alloy steel back-up rolls in four-high strip mills are rolling, in addition to steel, aluminum, brass, copper, and magnesium, and are successfully producing flat rolled products at less cost per ton of steel rolled.

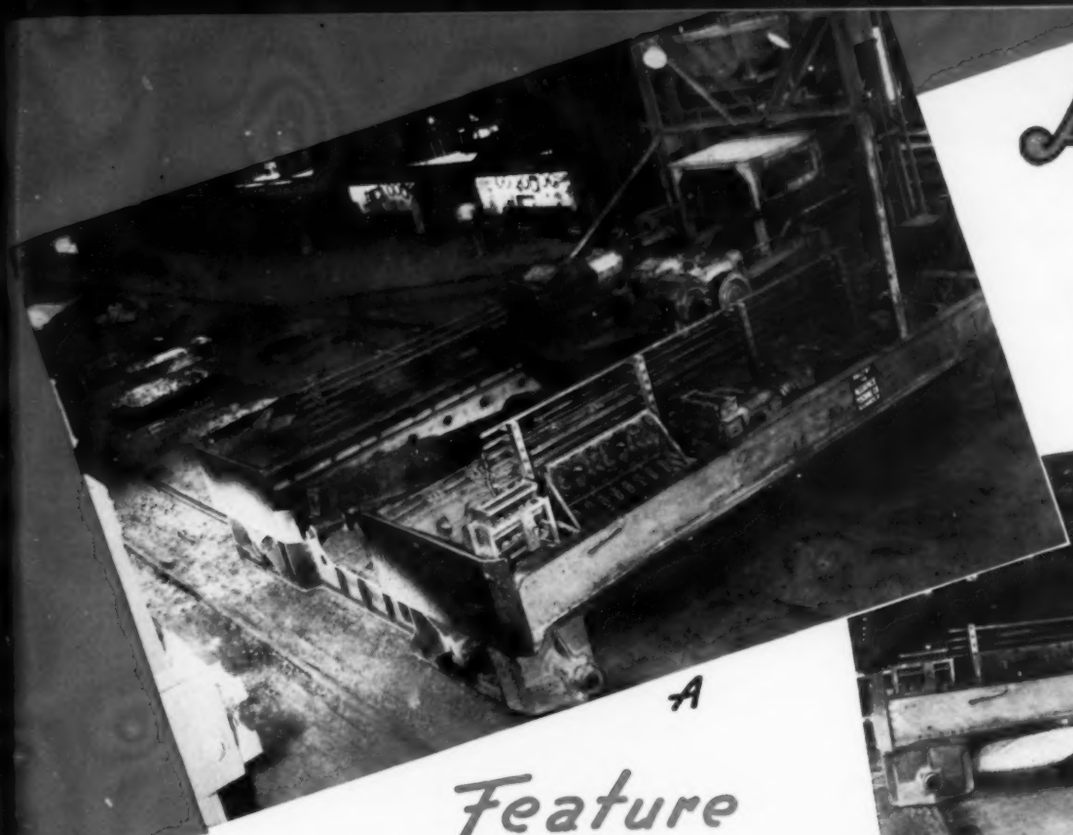
FOUR...FIVE...SIX THOUSAND FEET PER MINUTE

As speeds go higher in continuous strip mills, roll changes and shut-downs become more costly. The durable qualities, strength, and finish of Phoenix rolls mean real savings.

PITTSBURGH ROLLS

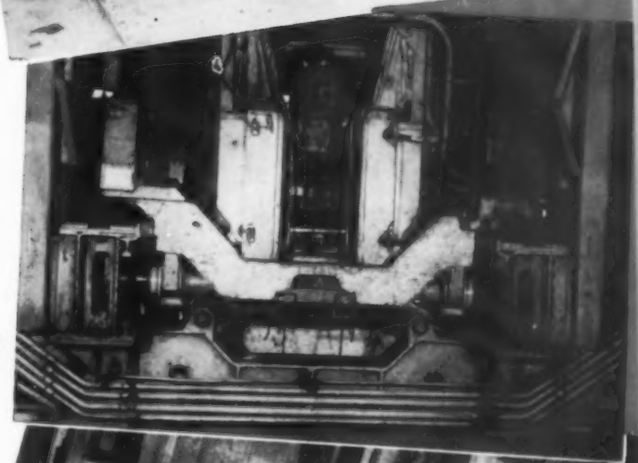
DIVISION OF BLAW-KNOX COMPANY, PITTSBURGH 1, PENNSYLVANIA

Alliance
OPEN HEARTH CHARGING MACHINES



A

B



C

D

E

Feature

A All gears and pinions operate in a bath of oil.

All mechanical parts and motors easily accessible.

Main girder consists of two wide flange beams welded to form a box section with diaphragms spaced approximately 3″ apart. Shown in detail in View "C."

Auxiliary girder wide flange beam.

Bridge machinery deck plate fastened to bottom of main and auxiliary girders and end truck gives necessary lateral stiffness and provides space for gear boxes, motors and control equipment.

Heavy buffer plates at front of charger protects ends of girders from projecting charging boxes.

Flexible coupling installed between all motors and gear boxes.

B Adequate clearance between bottom of girder and charging floor allows machine to pass over charging boxes and miscellaneous materials.

Operator has clear view of charging floor.

C Operator controls charging machine from seated position.

Magnetic controls and hydraulically operated lock rod give operator fingertip control of all motions.

Two sets of wheels at rear of trolley, one set bearing against lower rails and the other set bearing against the upper rails, protect the operator from shock.

D Operator's unobstructed view of furnace door, charging box and peel.

E Spring loaded pitman on hoist motion prevents breakage of peel.

THE ALLIANCE
MACHINE COMPANY

MAIN OFFICE
ALLIANCE, OHIO

PITTSBURGH OFFICE
1622 OLIVER BUILDING, PITTSBURGH, PA.

Problem - Reduce bearing maintenance and replacement costs.
Solution - Install A·B·K Laminated Plastic Bearings - they're water lubricated - outwear metal!

● When A-B-K Laminated Plastic Bearings replace conventional steel mill bearings, savings begin *immediately*.

First, cost of lubricating oil is eliminated entirely. A-B-K bearings are successfully lubricated with *water*.

Second, A-B-K bearings cut power consumption from the start.

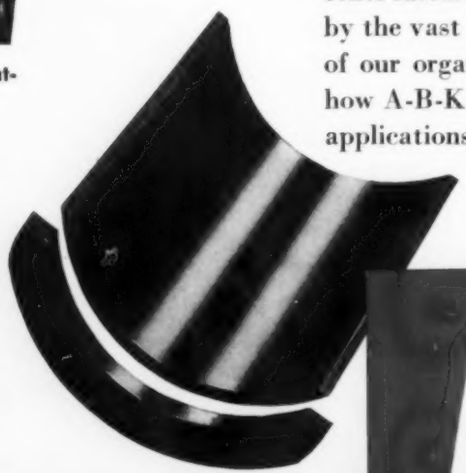
Third, A-B-K bearings hold gauge longer —require fewer adjustments—reduce costly shutdowns.

Fourth, A-B-K Laminated Plastic Bearings actually outwear metallic bearings. The material in these bearings is exceptionally tough and slow-wearing. It will not distort under shock and is highly heat-resistant. Actually polishes—never scores—the shaft!

Add up these advantages of A-B-K Laminated Plastic Bearings in terms of dollars and cents *saved*. An A-B-K representative, backed by the vast research and engineering facilities of our organization, will be glad to tell you how A-B-K bearings can cut costs on specific applications in your mill.

A-B-K slipper bearing with patented reinforced edge.

Phantom view of slipper bearing.



A-B-K roller neck bearing with separate collar.

AMERICAN Brake Shoe COMPANY

AMERICAN BRAKEBLOK DIVISION
DETROIT 9 MICHIGAN

A·B·K
Laminated Plastic Bearings

PRODUCT *Information*

ON ANY OF THE PRODUCTS MENTIONED IN THIS ISSUE

Below is an index of products referred to in editorial and advertising pages of this issue. If you desire additional information on any of them, use one of the accompanying postcards in requesting it. In each case give name of product and page number. The information will come to you directly from the manufacturer involved.

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IRON AND STEEL ENGINEER December, 1948

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Address..... City..... Zone.... State.....

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1010 EMPIRE BUILDING

PITTSBURGH 22, PA.

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IRON AND STEEL ENGINEER

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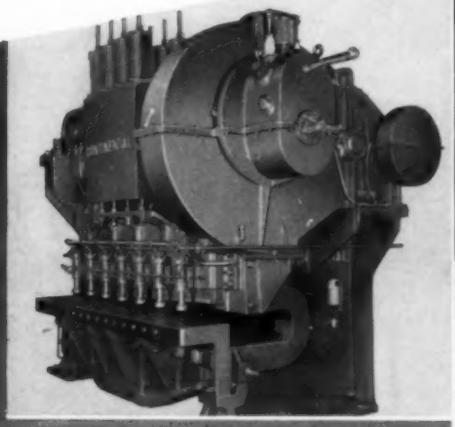
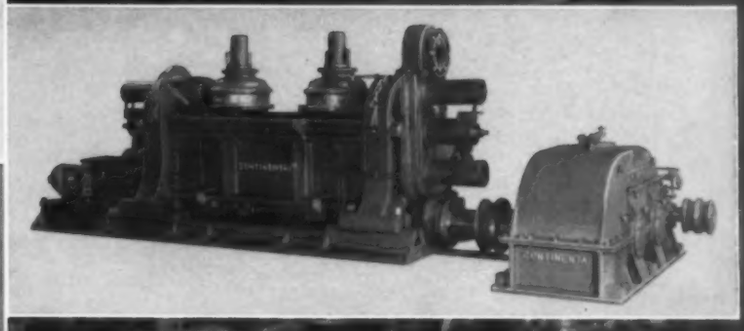
PITTSBURGH 22, PA.

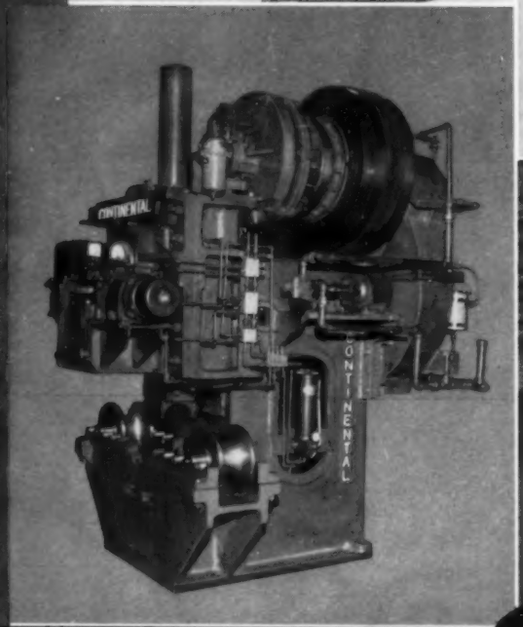
A Specialty!

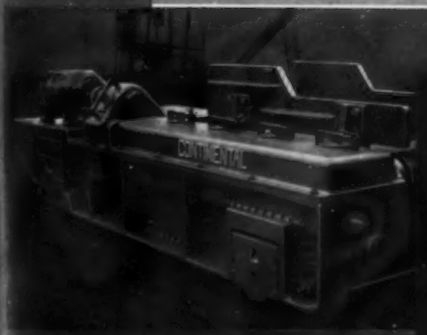
STEEL PLANT EQUIPMENT

Custom Engineered for Steel
Plant Expansion and Modernization









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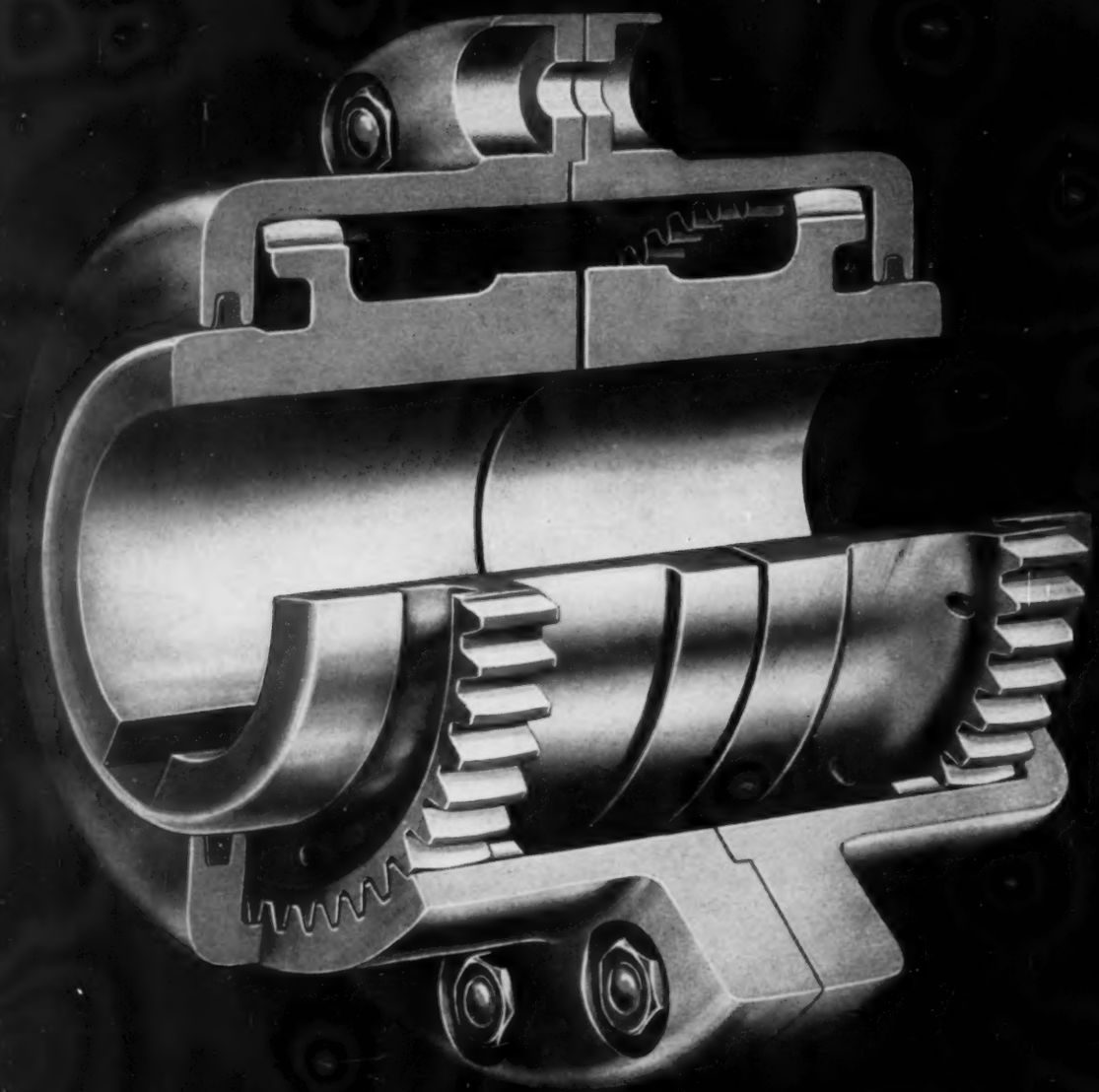
CHICAGO • PITTSBURGH

Industry's Headquarters for
Carbon and Alloy Steel Castings
Rolling Mills and Equipment
Iron and Steel Rolls

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

PALLET STACKING MOTO-TRUC

PALLET STACKING MOTO-TRUC

Move materials faster, safer and at a saving with Battery Electric Trucks and EXIDE-IRONCLAD® BATTERIES

Put battery electric trucks to work saving and earning for you. In thousands of plants, with material handling problems like yours, they are helping to boost production and cut costs. In fact, industrial management has found that materials handling is one of the few remaining fields where major economies can be effected.

Battery Electric Trucks can save time, manpower and money for you in loading and unloading cars and trucks . . . in handling materials in process . . . in hauling and tiering in warehouse . . . in *every* materials handling job from receiving to shipping. And for dependable, long-lasting power, equip your trucks with Exide-Ironclad Batteries, the batteries that assure full shift dependability, day after day, year after year.

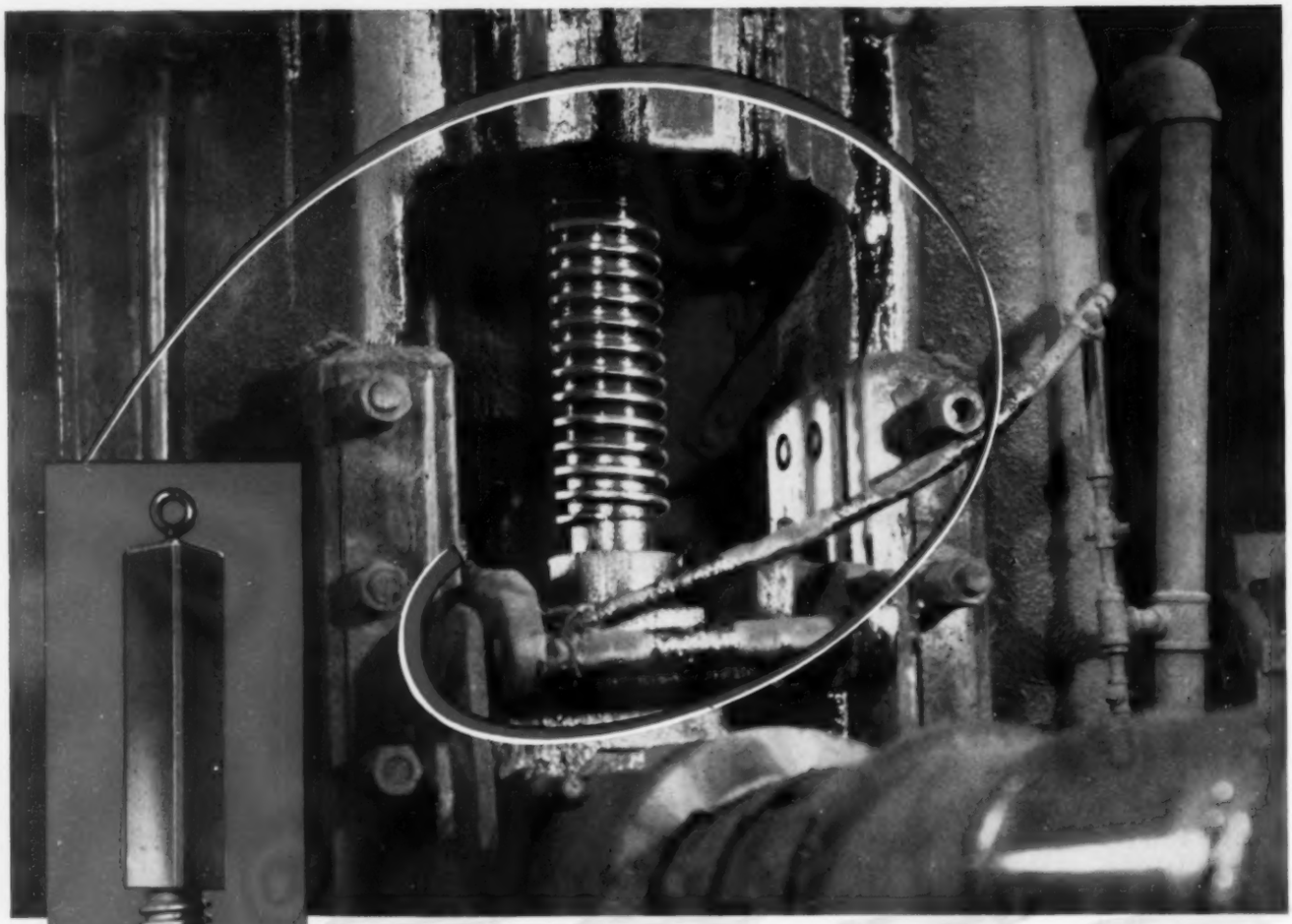
Exide-Ironclad Batteries have ALL FOUR of the vital characteristics of an efficient storage battery—high power ability, high electrical efficiency, ruggedness and long life.

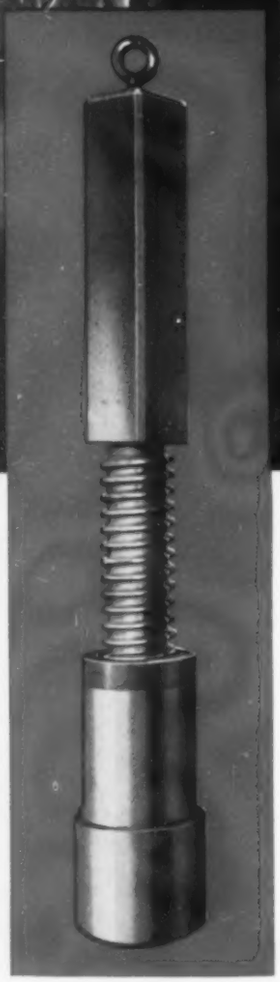
Write for further particulars and FREE copy of Exide-Ironclad Topics. It covers latest developments in materials handling and shows actual case histories.

DEPENDABLE POWER

1888 . . . Dependable Batteries for 60 Years . . . 1948

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia 32 • *Exide Batteries of Canada, Limited, Toronto*





"TOOL STEEL" PROCESS SCREW DOWN SCREWS AND NUTS SLASH TONNAGE COSTS!

***Compare* these typical results:**

BLOOMING MILL		TONNAGE	SERVICE LIFE RATIO
40"	"TOOL STEEL" SCREWS	4,453,395	12 to 1
	CARBON STEEL SCREWS	371,892	
36"	"TOOL STEEL" SCREWS	3,495,515	3½ to 1
	TORCH HARDENED SCREWS	985,055	
32"	"TOOL STEEL" SCREWS	5,327,581	13⅓ to 1
	CARBON STEEL SCREWS	400,000	
40"	"TOOL STEEL" SCREWS (World's Record)	7,257,400	9⅓ to 1
	CARBON STEEL SCREWS	783,741	

"Tool Steel's" tonnage superiority has likewise been proved on plate and slabbing mills!

Greatly increase *your* tonnage through minimized "down-time"—investigate these cost-saving facts today!

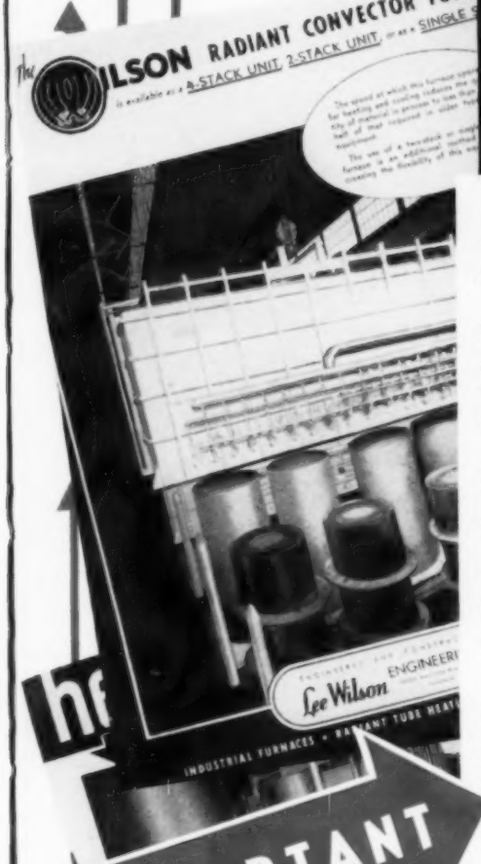
"TOOL STEEL" PROCESS

The Standard of Quality

for GEARS • PINIONS • ROLLS • SPROCKETS • WHEELS *and other* HARDENED PRODUCTS

THE TOOL STEEL GEAR & PINION CO.

CINCINNATI 16, OHIO



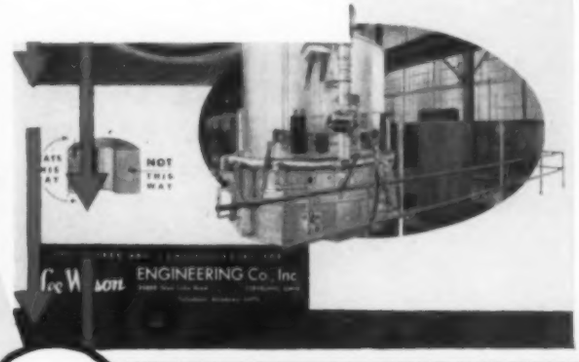
As a steel mill operator, do you know what convection annealing means to you?

The Lee Wilson Engineering Company, Inc., developed this system of heat application to coiled strip and tin plate.

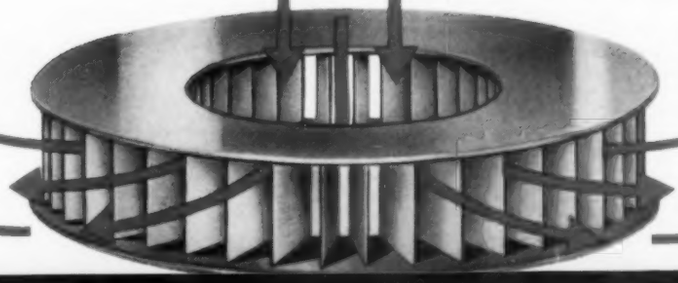
Each furnace of this type will anneal 2½ times the amount of steel coils that older types of equipment produce, and cool the charges in approximately the same time as required for heating.

Only your own desire for better production at lower costs limits what the Lee Wilson radiant convector annealing system can do for you.

IMPORTANT



ILSON CONVECTION HEATING FOR COILED STEEL ANNEALING



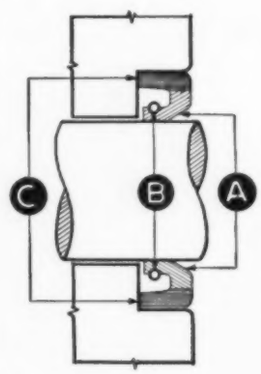
What—...AN OIL SEAL THAT'S Flexible?

TWIST IT . . . squeeze it . . . drop it . . . hammer it—the new one-piece concentric molded J-M Clipper Seal has plenty of give and take to help it stand up in service.

This flexibility has its advantages. The Clipper Seal's hard, tough outer heel, for example, is resilient enough to conform even to a slightly out of round cavity. Yet the soft, pliable *inner* lip always maintains a light, but positive sealing pressure on the shaft, with minimum wear on the seal.

The simple design of Clipper Seals also assures quick, easy installation, and permits removal without damage so that the seal may be used again. And because Clipper Seals are entirely non-metallic, they eliminate any possibility of electrolysis or corrosion.

Clipper Seals are made in both split and endless types . . . are available for shafts in sizes from ¼" I.D. up to 68" O.D. They are for sealing against oil, grease, water, coolants at operating temperatures up to 450°F. Write for folder PK-31A to Johns-Manville, Box 290, New York 16, N. Y.



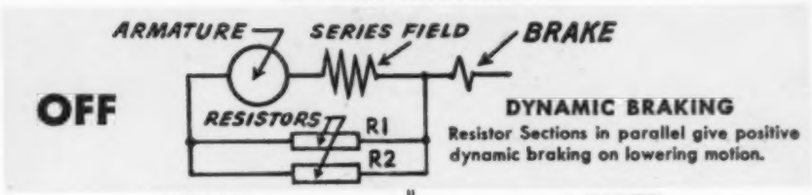
Here's how *Clipper Seal* works:

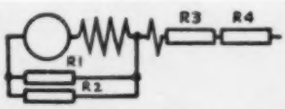
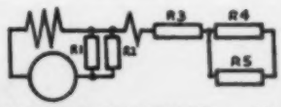
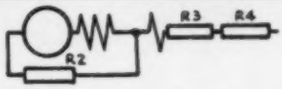
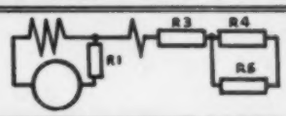
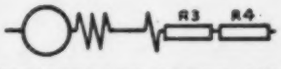
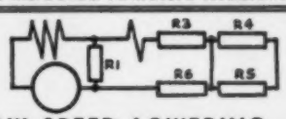
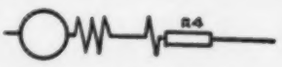
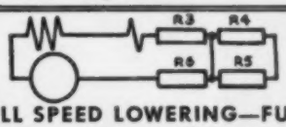
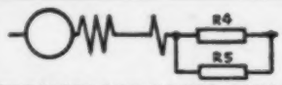
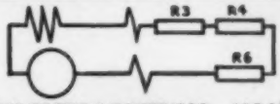
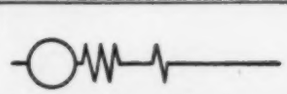
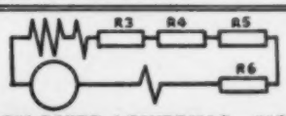
The lip (A) is held in light but firm contact with the shaft by means of a specially designed garter spring (B). Pressure on shaft is carefully pre-determined to minimize wear, yet effectively seal against leakage. The heel (C) provides a press fit in the cavity, assuring a tight lubricant-retaining seal at this point also. This design is readily varied to meet special conditions.

Johns-Manville **PACKINGS & GASKETS**

New DYNAMIC LOWERING NETWORK SYSTEM FOR HOIST CONTROL

OPERATION



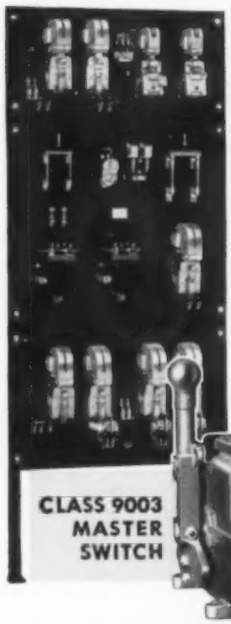
HOIST	LOWER
1H  SLACK CABLE POINT . . . Double Armature Shunt	 1L LOW SPEED SPOTTING . . . Heavy Field, Regenerative Action
2H  LOW SPEED-LIGHT HOOK . . . Single Armature Shunt	 2L INTERMEDIATE SPEED SPOTTING . . . Increased Armature Resistance
3H  INTERMEDIATE SPEED-LIGHT LOAD . . . Series Resistor	 3L LOW SPEED LOWERING . . . Network, Bridge Connection
4H  LOW SPEED-HEAVY LOAD . . . Series Resistor	 4L FULL SPEED LOWERING—FULL LOAD . . . Network, Potentiometer Connection
5H  INTERMEDIATE SPEED-HEAVY LOAD . . . Series Resistor, Parallel Connection	 5L HIGH SPEED LOWERING—HEAVY LOAD . . . Full Field
6H  FULL SPEED . . . Across-the-line	 6L HIGH SPEED LOWERING—LIGHT LOAD . . . Field Weakening

Safer. Two spring closed contactors and resistor sections in parallel insure positive dynamic braking on lowering motion.

More Control over hook. Double armature shunt makes slack cable and low speed—light hook points individually adjustable. Series relay provides for high speed lowering of heavy load with full field stability, and yet permits field weakening necessary for high speed lowering of light loads.

Reduced Maintenance. Network circuit is designed for low current peaks during motor acceleration. Maintenance is minimized on control contactors as well as on motor commutator and brushes. Only nine contactors are required for control system.

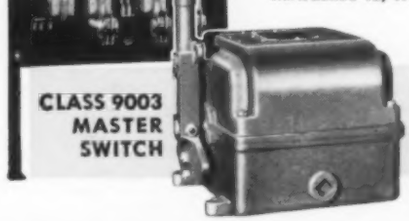
Less Space for resistors. Network system is designed for maximum use of resistor sections, and reserve capacity can be provided within reasonable dimensions.



Class 7954 Dynamic Lowering Hoist Control Panel

Only nine contactors are needed to give better hook control with the new network system.

Write for descriptive Bulletin 7954. Square D Company, 4041 N. Richards Street, Milwaukee 12, Wis.

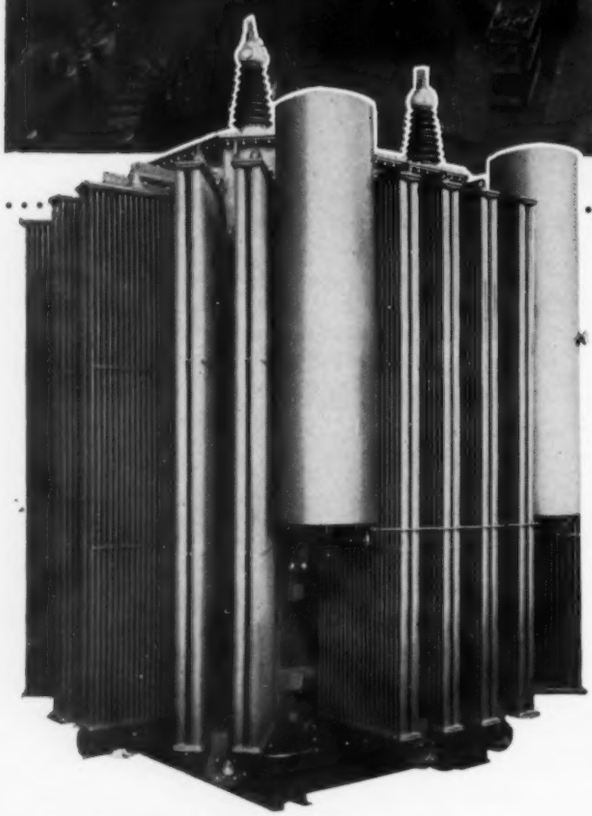


CLASS 9003 MASTER SWITCH

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D. F.



20,000-kva self-cooled and 25,000-kva forced-air-cooled transformer, typical of Wagner design and manufacture.

....."Built by Wagner"....

means - it's dependable!

Wagner, a pioneer in the development of transformers, has the experience, background, and facilities to build transformers for every need. Wagner transformers have been known for their dependability for over fifty years. During this time they have established a reputation for excellent performance in electric power systems throughout the country.

Wagner Transformers are dependable because they are liberally designed with extra factors of safety, constructed of carefully selected materials, and are skillfully engineered, built and tested in Wagner's transformer shops.

Users of power transformers will find it to their advantage to consult Wagner on their next transformer installation. Users of Wagner transformers also profit by our quick, convenient, nationwide service facilities. Twenty-nine branch offices, located in principal cities and manned by trained field engineers, are ready to serve you. Write for Bulletins TU-180 and TU-181 for information on the complete line of Wagner Transformers.

Wagner Electric Corporation

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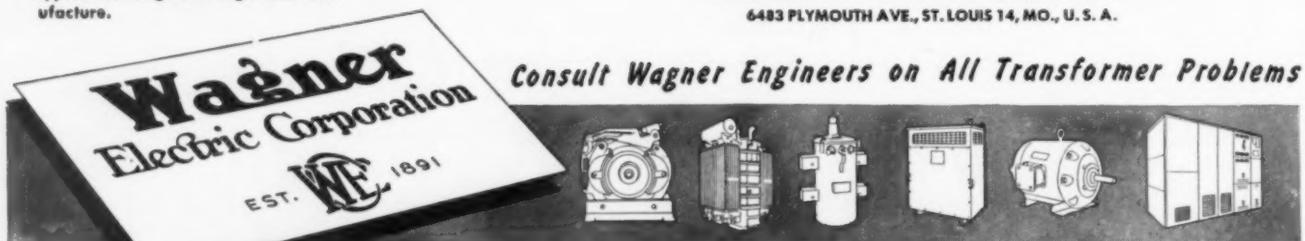

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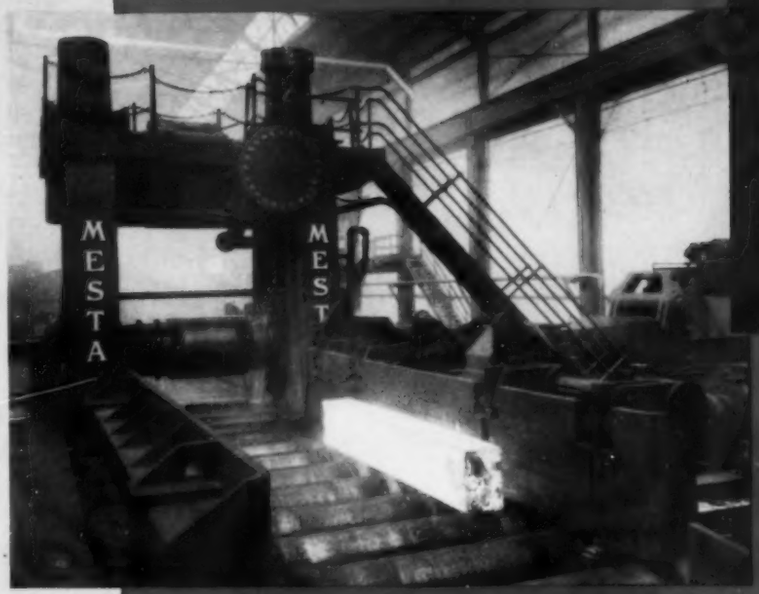

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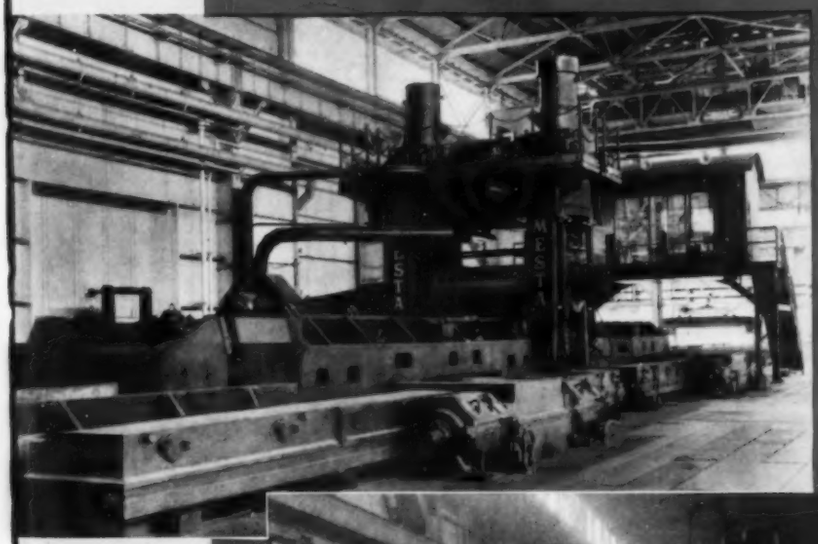

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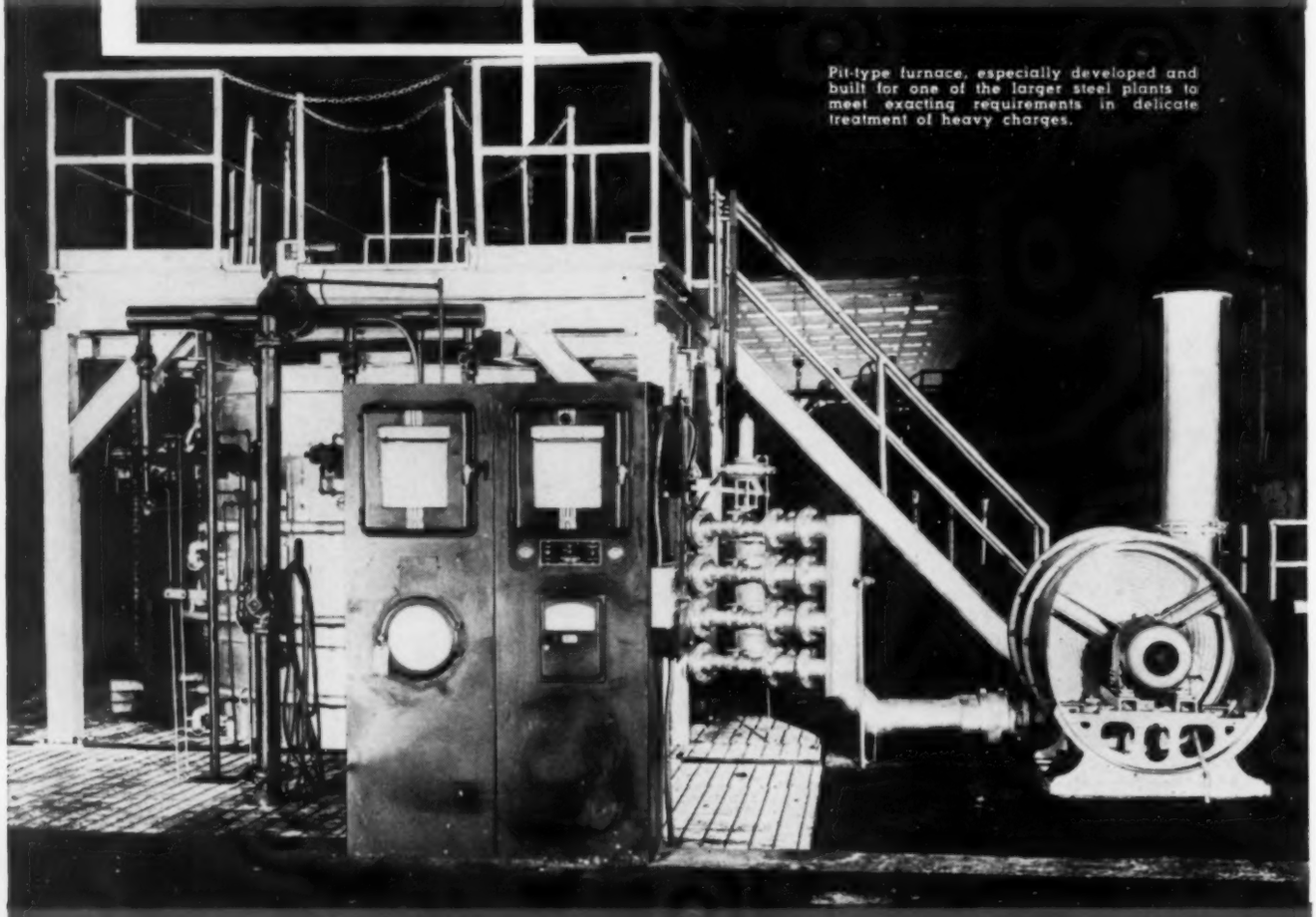

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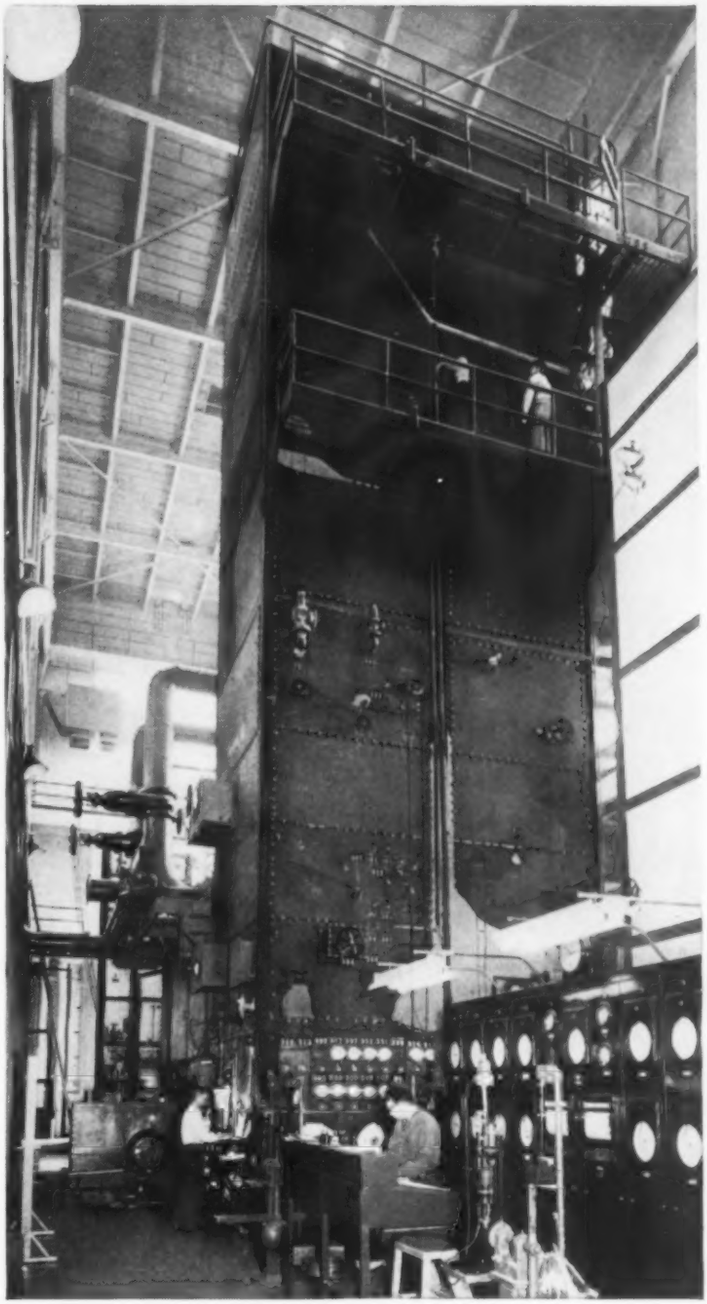

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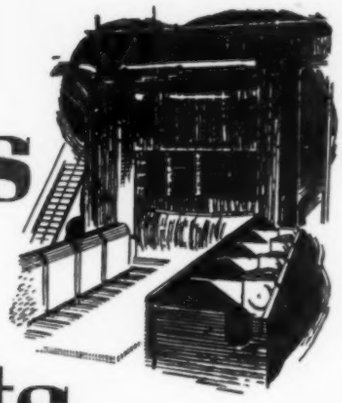


CURRENT steel production records may be attributed to the availability of greater quantities of scrap, according to the Institute of Scrap Iron and Steel. Purchased scrap for 1948 may hit a new record of 29,000,000 tons, 15 per cent above last year. This supply comes principally from automobiles, farms, wrecking operations, collectors, etc., plus about 7,000,000 tons from manufacturing operations and 4,000,000 tons from railroads. It is estimated that home scrap will only slightly exceed the 28,000,000 tons of 1947.

▲

IF you're inclined to worry about all the things the experts are predicting the administration in Washington will do next year, just remember that the gentlemen speaking are, for the greater part, the same experts who had Dewey practically moved into the White House.

▲

A federal trade commissioner, L. B. Mason, was recently quoted in the newspapers as saying the commission could make business "really sweat blood before it gets out of our clutches." He stated that a major portion of the nation's business structure can be prosecuted on charges of illegal price practices. He said it is not necessary for the commission to show a violation of anti-trust laws to start prosecution, but only to cite just a possibility of injury to competitors because of a firm's pricing methods.

Since Mr. Mason has earned the title of "dissenter" of the commission through his championing the rights of business, the foregoing statements probably do not represent his own inclinations, but rather reflect the commission's attitude, with which he usually disagrees. The commission has consistently avoided giving helpful advice to businessmen who desire to keep out of trouble, but on the other hand has apparently preferred to wait until the law is transgressed — even though unwittingly — and then bring suit. It is an attitude that can be only harmful to the economical health of our country, and it should be stamped out.

▲

AMONG all the post-election reasons advanced for the Republican upset, the one we like best is Governor Earl Warren's: "President Truman got more votes."

Of course, we might also say that the Republicans gallup-ed in the wrong direction.

▲

SOME good advice for business and industry in general comes from B. H. Namm, president of Namm Stores in Brooklyn. Business, he urges, must sell itself as well as its products to the American people, who want facts about profits, costs, taxes, capital requirements, etc. Business must become militant and vocal, and take people into its confidence, in simple words.

▲

ALTHOUGH we have consistently refrained from printing compliments and "puffs" that come to us, the following excerpt from a letter from James Dale, blast furnace consultant in the British Isles, to S. E. Graeff, of the Steel Company of Wales, seems too good to keep: "It (the Association of Iron and Steel Engineers) is a grand organization . . . . It has been of more assistance to the British iron and steel business than many other societies, and as one fellow said: 'Had I paid as much attention to my Bible as to the IRON AND STEEL ENGINEER journals, I would have been Archbishop of Canterbury.' I think I would have been Archbishop of York."

▲

THE third blast furnace at Ford Motor Company, which went into blast recently, was christened the William Clay Ford. The two original furnaces at this plant are named the Henry and the Benson. Perhaps this adherence to male names instead of the usual feminine tags makes the furnaces less temperamental.

▲

LETTERS from L. R. Milburn, past president of AISE and now in Seoul, Korea, indicate that the U. S. power mission which he heads up there faces some knotty problems. One of the basic problems stems from the fuel, which is an anthracite coal containing 40–45 per cent ash. In the largest steam plant, which contains four 25,000 kw turbo-generators, it is difficult to maintain a 40,000 kw output because of the fuel.

▲

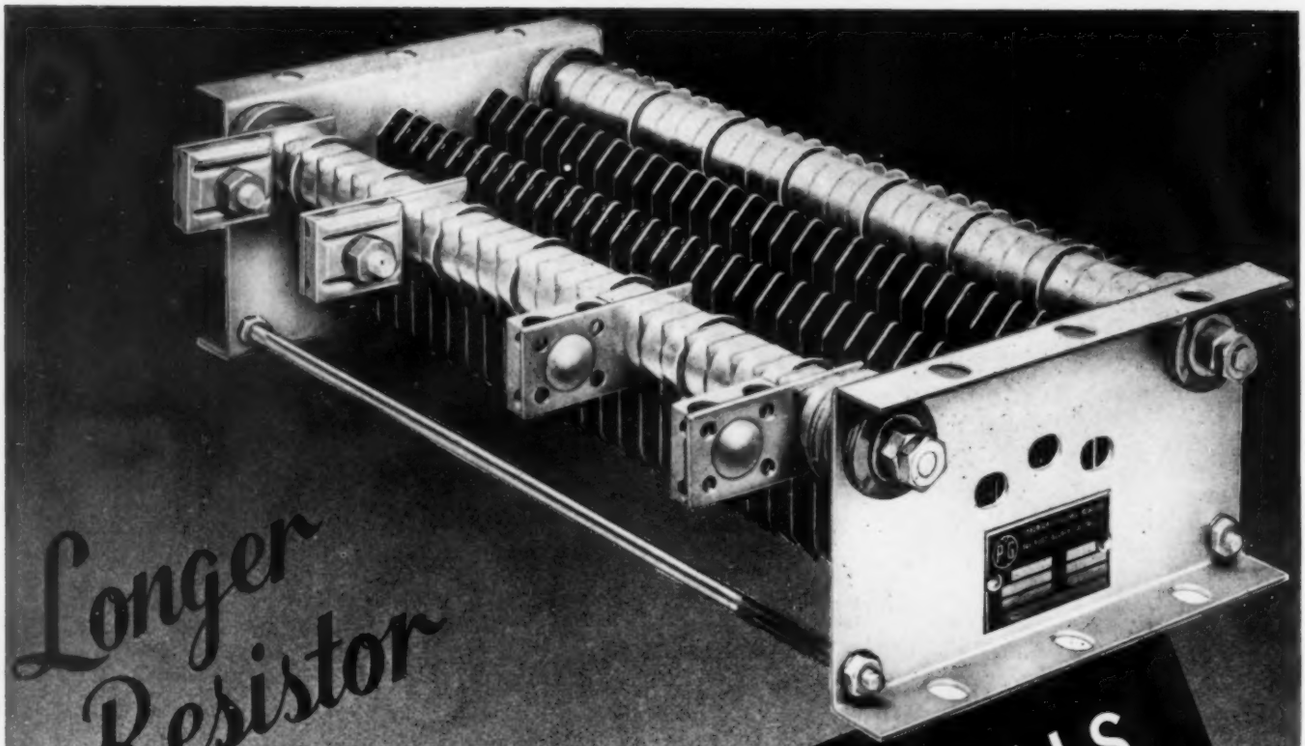
ACCORDING to the American Iron and Steel Institute, maintenance and repair charges of the steel industry during 1947 reached an all-time record of $692,200,000, 41.3 per cent above 1946. This works out to $10.46 per ton of hot-rolled product, against $9.62 in 1946.

▲

A RECENT automotive strike was based upon the installation of equipment that raised the daily production of the workers. Yet these same individuals are probably already moving toward a fourth round of wage increases. We don't know how it's going to be done, but labor must be made to understand that any *real* increase in wages can come only from greater production. British labor unions have come to realize this, and are reversing their original stand against more mechanization.

▲

WE have often commented upon the fact that steel industry operations must be big if economy is to be attained. A recent survey, which indicates relative size, shows that 1000 metal-working plants containing 9300 furnaces, use 2¾ billion cubic feet of gas per month, while 97 steel plants use 6 billion cubic feet per month.



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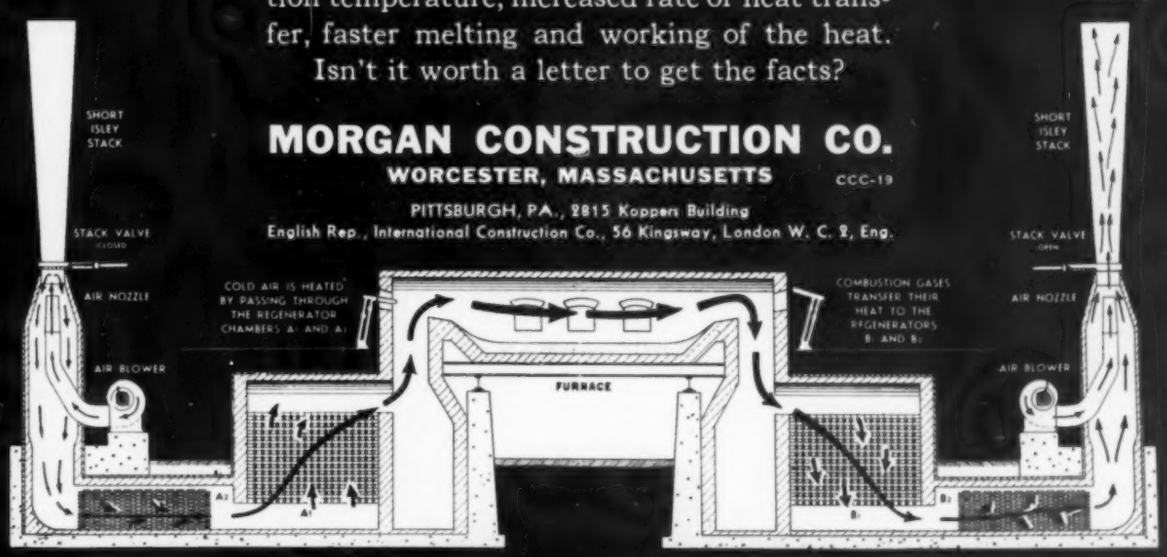

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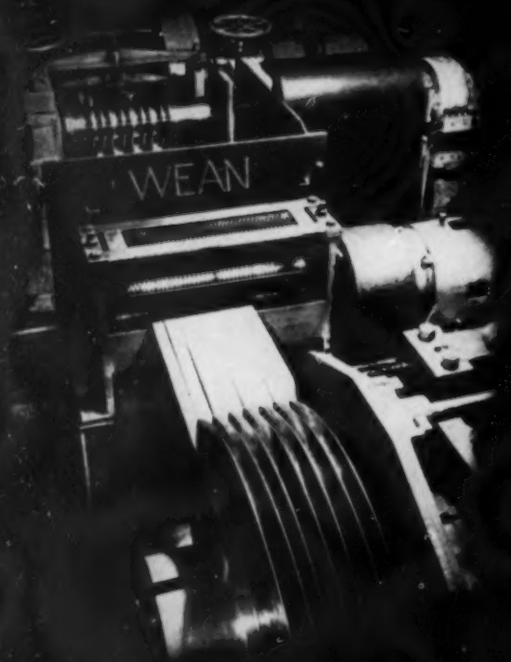

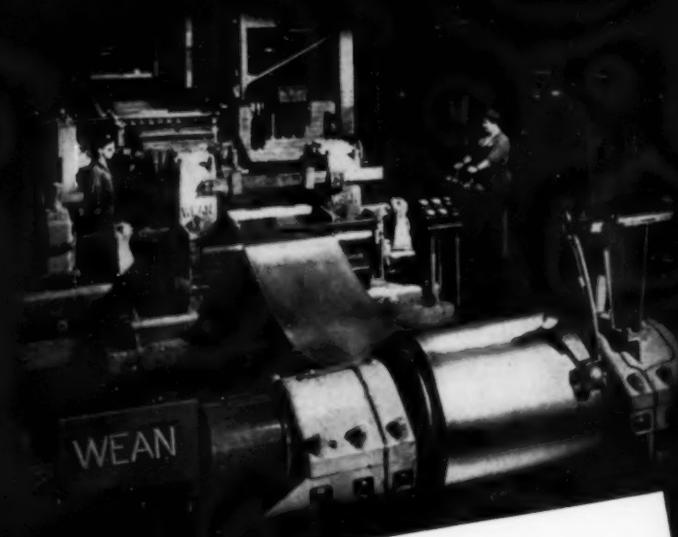

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Iron and Steel ENGINEER

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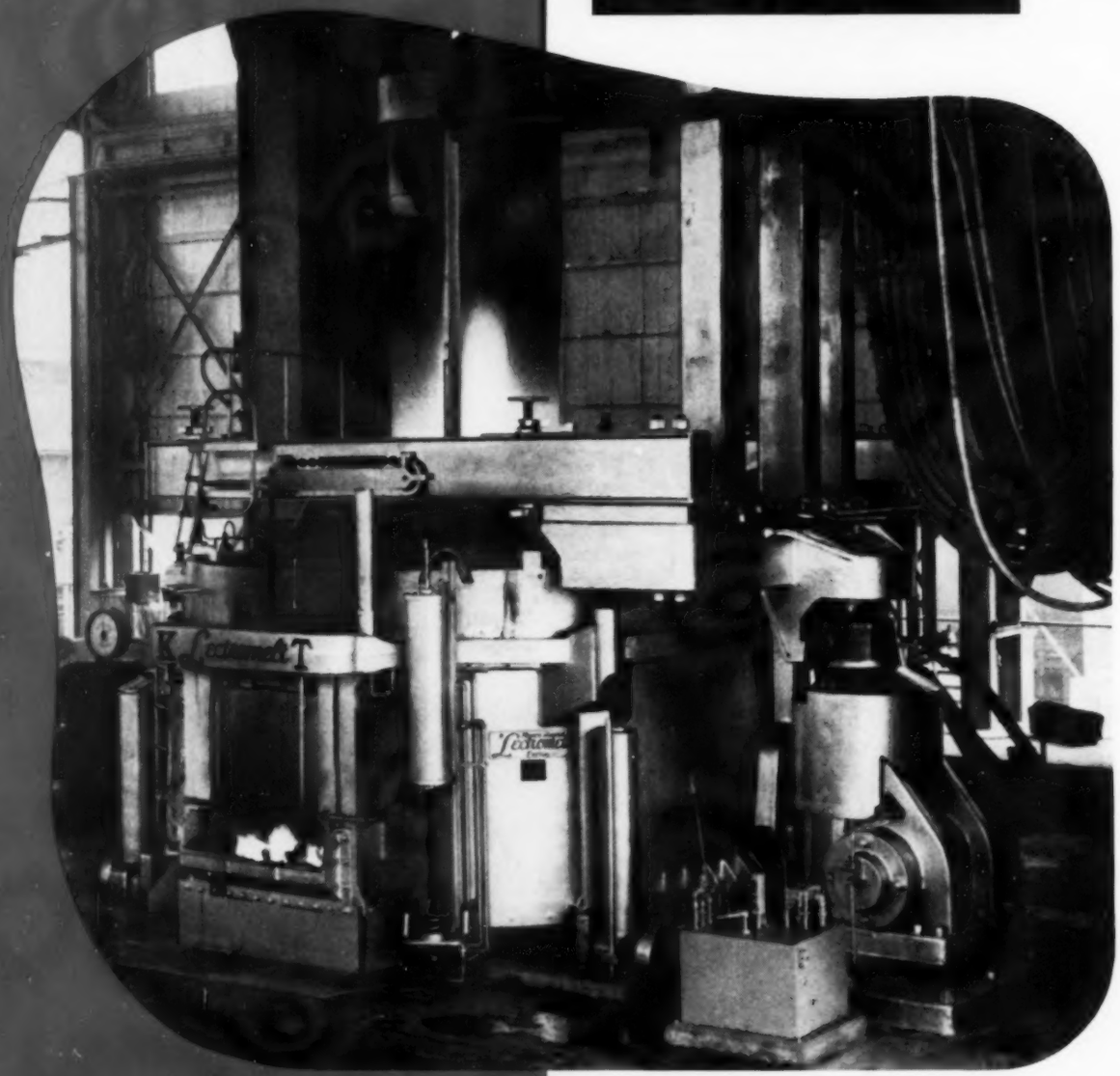

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The Manufacture of Wrought Steel Wheels

By W. A. ASHTON, Superintendent
Wheel and Axle Division
Carnegie-Illinois Steel Corporation
Munhall, Pennsylvania
and
R. N. MERK*, Assistant to Chief Engineer
Carnegie-Illinois Steel Corporation
Munhall, Pennsylvania

. . . . reviewing developments and practices in the manufacture of wrought steel wheels and forged circular sections for transportation equipment . . . .

▲ THE casting of wheels from iron began around the 15th century in Germany and England. Some wheels were laboriously produced by forging the iron to finished diameter by sledging on an anvil, as in forging a tire. The chilled iron wheel was used as cast for some time until the tire mill was invented in Europe. The first locomotives had wooden wheels and flat iron tires, which were formed and crudely welded by sledging on an anvil. When the first railroad was built in America by the Baltimore and Ohio in 1828, a flange was formed on the tire, by making the tire of greater width than required, and hammering the metal out to form a flange. This enabled the engine and cars to stay on the flat iron track, which was fastened to timber laid lengthwise to the rail. Development of the tire mill dates from around 1853 in Germany and before 1860 in England. Shortly afterward one or two mills were installed in the United States for rolling, or truing up the bent and welded iron tires. The first forged and rolled steel tires were produced in this country in 1867, and were mounted usually on soft steel centers.

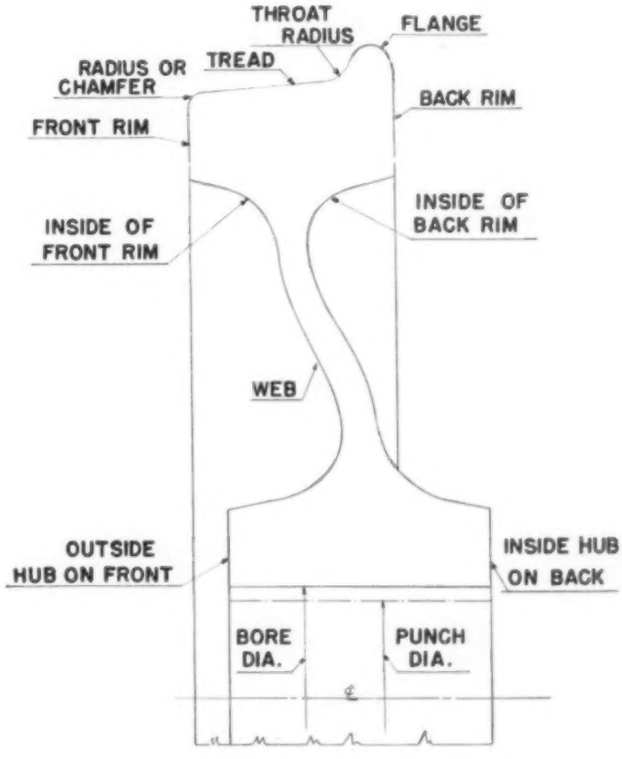
The chilled iron wheel was first made in the United States in 1836. Previous to 1900, locomotive and passenger car wheels were usually of steel-tired type similar to European practice, and freight car wheels were mainly of the old design of double-plate or Washburn cast iron type. The 10-ton (net) capacity of the early freight cars in the United States was increased with the development of a 15-ton car around 1882, followed by the 25-ton in 1885, 30-ton in 1887, and 40-ton in 1893. With the introduction of 50-ton capacity cars in 1896, chilled iron wheels, notwithstanding the many improvements made in their manufacture, were not strong enough to withstand the heavier load.

The wrought steel (or rolled steel) car wheel was first developed by Charles T. Schoen, and his associate Hendrik V. Loss, in 1902, after four years of experimentation. The first patent was taken out at that time by Mr. Loss, covering a machine for rolling car wheels from circular ingots. A second patent was issued to Mr. Loss in 1903, for a one piece forged and rolled steel wheel having the hub and approximately one-fourth of the adjacent web forged, the axle hole punched, and the remainder of the web and rim rolled to a finish. Mr. Schoen, the first builder of steel cars, organized the Schoen Steel Wheel Company for the manufacture of steel wheels, to meet anticipated demands for a satisfactory wheel under heavy capacity freight cars. The first wheels were produced at the Schoen plant in McKees Rocks, Pennsylvania, in December, 1903. For about nine months, individually cast circular steel ingots were used for wheel blocks. The process was changed in the fall of 1904 to forging and rolling from a square rolled steel slab. This was continued until 1911, when the invention of a circular shear by E. E. Slick permitted the economical shearing of rolled rounds of approximately 15 in. diameter into lengths required to produce the desired wheel size.

*Now with H. H. Robertson Company, Ambridge, Pennsylvania

Presented before AISE Annual Spring Conference, Philadelphia, Pennsylvania, May 26, 1947.

Figure 1 — Nomenclature of component parts of standard wheel.



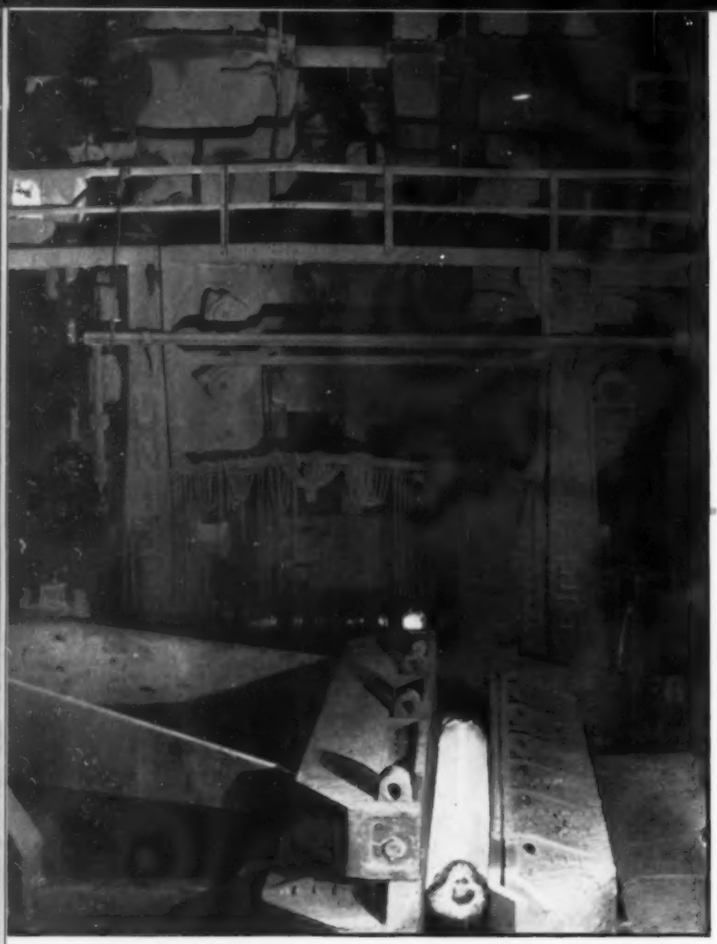
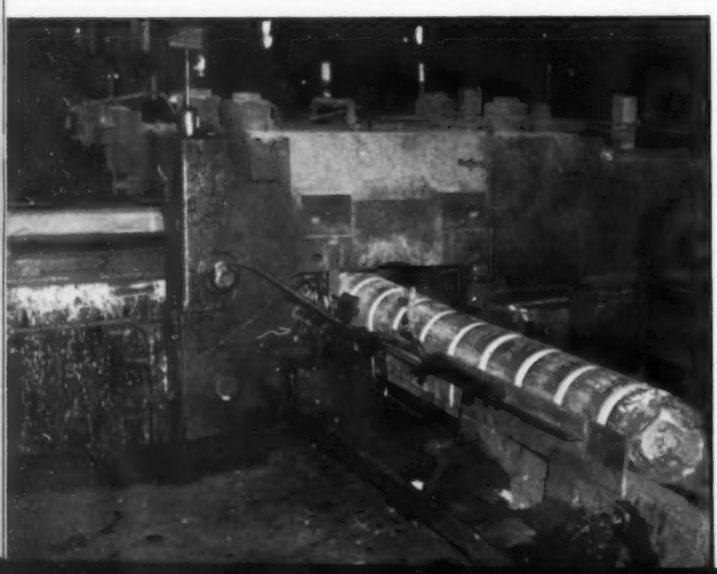


Figure 2 — Rounds for one wear wheels are rolled on this 54 in. blooming mill.

The Standard Steel Works Company began the manufacture of steel wheels in the early part of 1904. By 1908, over 200,000 wrought steel wheels were in service, and merits of the product were recognized. At this time the Schoen plant was purchased by the Carnegie Steel Company, and wheels were being made commercially by Midvale Steel Company, Standard Steel Works Company, and Forged Steel Wheel Company. These wheels were accepted by the railroads for usage under 70-ton capacity freight cars, which at that time were not satisfactory or safe with the use of chilled iron wheels.

Figure 3 — The hot nicking machine cuts the logs, as they come from the blooming mill, into wheel blocks.



In 1908, a mill designed by Mr. Slick was built at Homestead to roll wheels from 15 to 38 in. in diameter without forging, but this process was abandoned in 1919 for press forging. The principles of manufacture included the partial piercing of wheel blocks, cut from circular blooms, to permit insertion of a mandrel, followed by a combined rolling and pressing operation between companion dies until the wheel took the desired shape. The excess fin was sheared off, and punching of bore in hub removed the mandrel. This type of mill is now used by Bethlehem Steel Company for small circular sections. Wheel rolling mills in use today are of construction similar to the Schoen type, although the blank may be positioned in the mill either vertically or horizontally. As the vertical type of mill is used by this corporation, this process will be described later in detail.

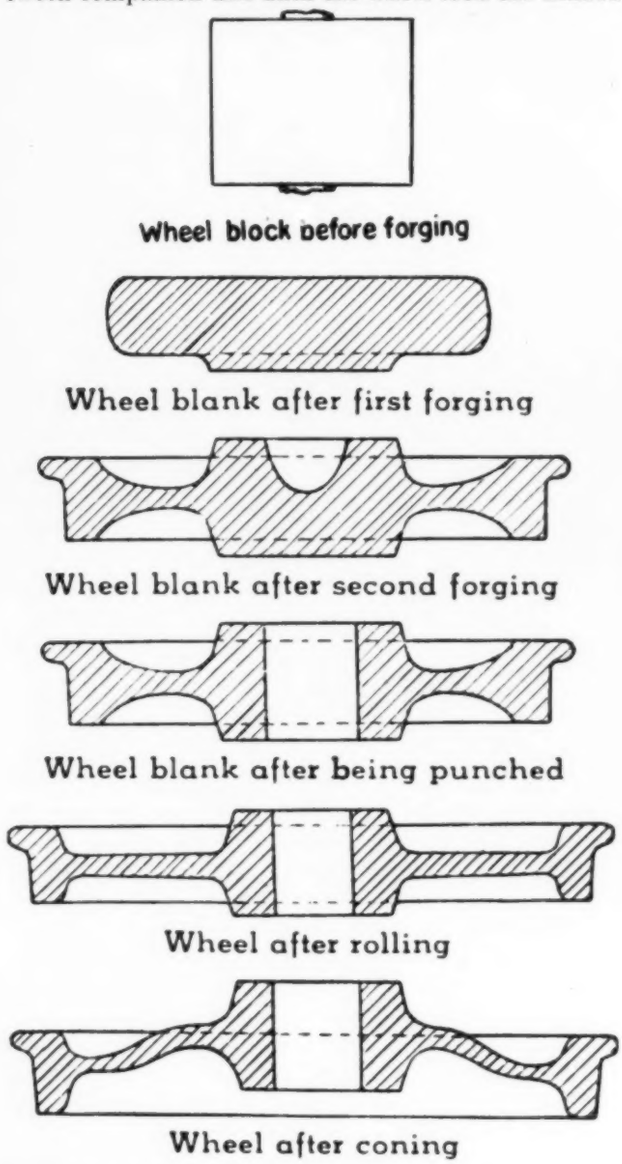

Wheel block before forging
Wheel blank after first forging
Wheel blank after second forging
Wheel blank after being punched
Wheel after rolling
Wheel after coning

Figure 4 — The steps in the transformation of a wheel block to a finished wheel are indicated in these six sketches.

It is possible to obtain wheel blocks by casting each individually as an ingot, by cold slicing the blocks from

fluted circular ingots, and by shearing from circular blooms. Since this corporation cuts practically all blocks from circular blooms, this process will be described later.

During the past 35 years, extensive improvements have been made in the processing of both chilled iron, cast steel, and wrought steel type wheels to meet the requirements of heavier wheel loads, higher speeds of transportation, and severe braking conditions. A portion of the cast wheels are now made of steel by a centrifugal casting process. The double plate of the chilled car wheel was replaced in 1928 with a single plate design, foundry equipment mechanized, and more rigid controls are now maintained over foundry operations. Wrought steel wheels are subject to rigid metallurgical controls at each step of manufacture. While originally mostly air cooled from forging temperature, wrought steel wheels are now cooled under certain manufacturer's controlled specifications, and if heat treated may be rim toughened, or oil quenched and tempered, to withstand more severe operating conditions, as will be described later.

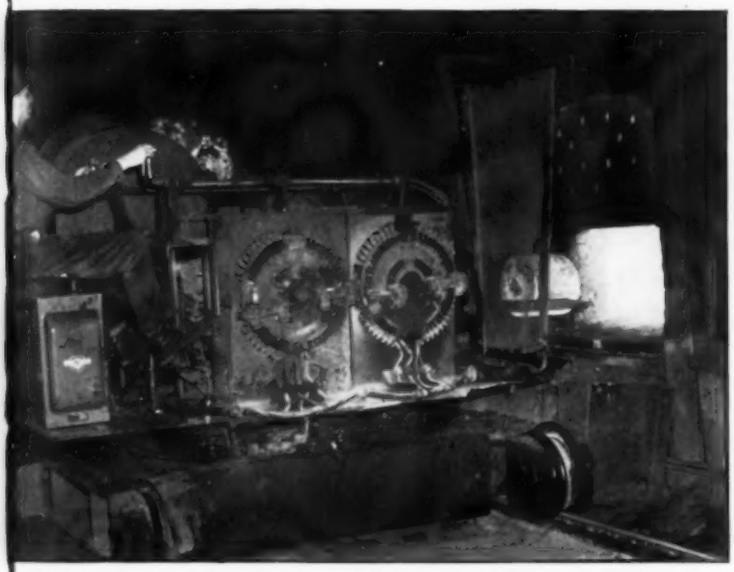


Figure 5 — A high speed floor charging machine is used to charge the wheel blocks into the heating furnace. Blocks have been heated up to 500 F in a tunnel type furnace before entering the heating furnace.

TYPES OF WROUGHT STEEL WHEELS

The component parts of a wheel are the hub, the web, the rim, the tread, and flange, as shown in Figure 1. The flange is single (on the inside of the wheel) for railroad and industrial car service, except where used for crane track wheels the flange may be double. Multiple wear wheels have a rim thickness of 2½ in. or over to permit machining two or more times for correction of worn tread and flange surfaces to the original contour. One wear wheels are designed with lesser rim thickness of approximately 1¼ in., not permitting retreading by machining once they have been worn to the condemning limit. The object of this wheel is to afford a lower first

Figure 6 — This figure illustrates the first forging operation and shows a centering device against the wheel block.

cost and to eliminate the necessity for retreading. Railroad freight car wheels are ordinarily one wear wheels with the contour of tread and flange commonly rolled to finish condition without machining in most cases, except when specified by the customer. One wear wheels were first designed and developed by Carnegie-Illinois Steel in 1925. Multiple wear wheels are manufactured to closer dimensional tolerances than one wear wheels, and are used for locomotives, tenders, passenger cars, and some freight cars. These are completely covered by standard specifications, including type and grade of steel, and may be heat treated or untreated, machined on tread, flange and hub faces, or machined all over.

Figure 7 — The full 7000-ton capacity load is used in the second forging operation.

Wrought steel wheels for railroad purposes conform to the following requirements as to chemical composition:

	Per cent
Carbon	0.65–0.85
Manganese	0.60–0.85
Phosphorus, not over	0.05
Sulphur, not over	0.05
Silicon, not less than	0.15

In multiple wear wheels for locomotives, tenders, passenger and freight cars, the carbon content and the Brinell hardness of rim (on heat treated wheels) are further controlled under three service classes, as given in specification No. M-123 of the Association of American Railroads.

MANUFACTURE OF WROUGHT STEEL WHEELS

The Carnegie-Illinois Steel Corporation manufactures car wheels in both Pittsburgh and Chicago districts. Car wheels up to 40 in. diameter are made at the Gary Steel Works in the Chicago district, and wheels up to 46 in. diameter along with miscellaneous circular sections at the Schoen plant in the Pittsburgh area, now known as the Wheel and Axle Division of Homestead District Works. Manufacturing processes from open hearth to finished wheel are similar for the two units, except where existing processing equipment necessitates deviation. Homestead practice will be used as descriptive of steps involved in the manufacture of wrought steel wheels.

At the open hearth, the steel is cast into hot top ingots of 25⅜ x 25⅜ in. cross-section x approximately 12,000 lb each. These ingots, after stripping and reheating in coke oven gas fired regenerative type soaking pits, are rolled into 17½ in. diameter rounds in a 54 in. blooming mill, or into 15 in. rounds on either the 44 or 54 in. blooming mills. The 15 in. rounds are used for making one wear wheels, rolled electric wheels, resilient wheel tires, and certain circular sections. The 17½ in. diameter rounds are used for multiple wear passenger and freight car wheels, locomotive, tender and engine truck wheels, and circular sections. Figure 2 shows the rolling of wheel rounds on the 54 in. blooming mill. Dependent upon size of round and particular blooming mill used, the ingot is given from 6 to 10 flat passes, 4 oval passes, and one finishing pass. The rolled rounds, or "logs" as they are known, pass through a rotary brander for marking identification numbers along the entire length. The logs are cut into blocks of the proper weight for each wheel size in a hot nicking machine, shown in Figure 3, which is a special shear in which opposing upper and lower wedge shaped knives are driven through a pinion in opposite directions, and cut the rotating log almost in two, leaving only a core of about 4 in. diameter separating the individual blocks. This core allows handling of the wheel blocks in log form into slow cooling pits for gradual cooling from rolling temperature to around 300 F. The slow cooling operation produces wheel blocks less susceptible to internal flaking or ruptures. The logs are then inspected at the conditioning yard, surface conditioned if necessary with chipping hammers, and then fractured into block form. On each block that passes inspection the identification

Figure 8 — The hub pinch press punches a hole in the center of the hub.

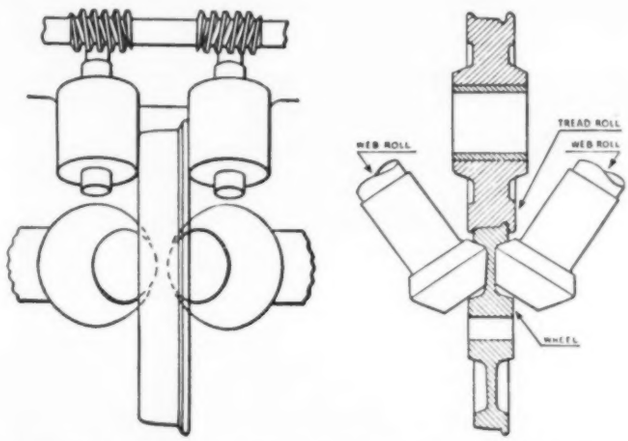


Figure 9 — The operation of a wheel rolling mill is shown in these two sketches. On left is an elevation showing rim rolls at top and web rolls at center. On right is a sectional plan view.

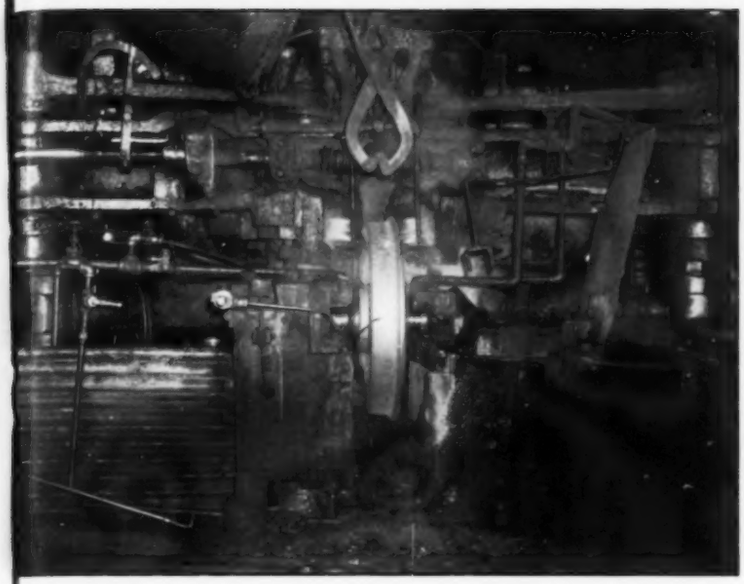


Figure 10 — Front view of wheel rolling mill.

Figure 11 — Side view of wheel rolling mill.

number and weight is painted, in addition to the branded identification, as further safeguard in maintaining steel identity. The blocks are then shipped in gondola cars to the Wheel and Axle Division at McKees Rocks, Pennsylvania.

At the wheel plant the blocks are stocked in separate piles, according to heat number and block weight until required for use. The steps involved in transforming a wheel block into a finished wheel can be followed in Figure 4, which shows the effect of first forging, second forging, hub punching, rolling, and coming operations.

When scheduled for forging or rolling, the blocks are loaded into specially constructed cast steel boxes, which are pushed through a tunnel type gas fired furnace that slowly heats the steel to approximately 500 F, prior to entering the heating furnaces. The preheating is required for this type of steel in order to avoid damage in heating cold blocks. The boxes of preheated blocks are emptied onto a platform, where the charging machine picks them up for charging into the heating furnaces. Blocks for one wear wheels are all check weighed at the platform to ascertain that each is within the desired weight tolerances. Four heating furnaces are used, each of five door regenerative in-and-out type with side natural gas firing. The heating cycle is varied, dependent upon the weight of block. Continuous temperature recorders aid the heater in maintaining maximum furnace temperature within safe limits. Blocks are heated to approximately 2000-2100 F.

Blocks are handled by a high speed floor type charger, shown in Figure 5, the trolley of which can turn in a 360 degree circle and is equipped with a rack operated peel with fork type grip for handling wheel blocks, whereby the operator can up-turn or knock them down with ease. Blocks are set on the base of the cylinder, with axis of cylinder vertical in the furnaces, to insure uniformity of heating for the first forging operation. The heated blocks are descaled by rolling the block over the stock bench while held in the fork type charger peel, or by holding with the charger in a descaler of the whirling chain type. The charger then deposits the block vertically in the bottom die of the first forging press, which is shown in Figure 6.

The first forging operation upsets the block, and does some forming of the web and hub so that the blank will center itself in the next operation. The top die is plain, and the bottom die corresponds to the outside face of the wheel. The effective capacity of the 7000-ton press, which is used without the intensifier for this work, is 3850 tons. The successive press operations consist of placing block vertically in bottom die with charger, centering of block vertically in die with hydraulically operated centering device while crosshead of press is lowered gradually until top die touches block, and then retracting centering device, applying the 675 lb and then the 2500 lb hydraulic water pressure, after which the pressure is released and the crosshead raised. The bottom jack is run out and blank ejected from lower die to permit attaching a jib crane hoist to blank for removing from die to bench at side of press. Dies are then cooled and cleaned, and the bottom jack run back under crosshead to complete the cycle.

A second charger with fork type peel charges the forged blank into either of two reheating furnaces, where the temperature is equalized and brought up again to approximately 2050 F. The furnaces are similar in construction to those described for blocks. The charger, after removing the blank from the furnace, without releasing its grip, moves to a mechanical descaler of the rotating chain type, prior to placing the blank in the second forging press.

In the second forging operation, the top die conforms to the inside of the wheel, and the bottom die to the outside of wheel. Since at the end of the stroke, in the operation of the press, the top and bottom dies practically meet, correct block weight is necessary in order to produce a forging suitable for subsequent rolling to a finished wheel. The press, as shown in Figure 7, is identical in design and capacity to the first forging press, except that the intensifier is used to increase the hydraulic pressure up to 4500 lb and obtain the full 7000-ton capacity. The manipulation of the blank in the press

Figure 12 — The stamping machine marks the wheel with the data which identifies the wheel and the manufacturer.

is similar to operations described for the first forging operation.

The blank is transferred on a gravity buggy, operating on a hydraulically tilted track, to the adjacent hub punch press, shown in Figure 8. This 750-ton press punches a hole in the center of the hub, leaving about one-half inch of stock all around to be removed later by rough boring. During the punching operation, the outer portion of the wheel hub is supported by proper fitting top and bottom dies to prevent distortion.

The next forming process is a rolling operation. For this purpose the wheel blank is again reheated in a four-door furnace to approximately 2050 F. Another floor type charger with a fork type peel handles the blanks from the hub punch to the reheating furnace and wheel mill.

At the rolling mill, the wheel blank is transferred from the charger peel to tongs suspended from a jib crane, which grip the wheel blank below the rim, and hold it in a vertical position while a mandrel is inserted through the punched hub. Then, resting on the mandrel, it is pushed back against the tread roll into position for rolling. In Figure 9, the sectional plan view and elevation illustrate the principle of operation of rolling mill. The power driven web rolls and the idler rim rolls are brought into proper position from both sides against the wheel blank. The mill is now ready for rolling, the blank being rotated by the power driven web rolls, operated by a 750 hp variable speed motor through a geared jack shaft. The pressure of the web rolls against both sides

Figure 13 — The coning press changes the wheel from a plain disc shape to a deformed cone shape.

Figure 14 — The wheels are slow cooled in an equalizing furnace in order to eliminate residual stresses in the wheels.

of web and underside of rim, forces the rim outwards against the groove of the tread roll, which forms proper size and desired contour of tread and flange. This increases the diameter, and the wheel moves forward on its sliding mandrel, in opposite direction to the tread roll, until the tread comes in contact with the pointer of the gage, preset to the desired tread diameter, whereupon the roller stops the mill, and retracts the rolls to permit removal of the wheel from the mill. The gage for calipering the wheel is attached to the mill housing, and the hinged pointer can be raised out of the way prior to entering or removing wheels from the mill. During the rolling process a hydraulic jet of 675 lb pressure is applied against the tread of the wheel to prevent rolled-in

scale. Water is also applied to web and hub for the same purpose. The rolled wheel is again attached to the tongs on the jib crane, raised to allow removal of mandrel, and placed on a motor operated transfer buggy. Figure 10 is a front view of mill, showing location of top rim rolls, the tread diameter gage, and of a second gage indicating the rim width (upper left side of picture). Figure 11 shows a side view of mill.

An adjacent stamping machine, shown in Figure 12, stamps the inside face of the rim with markings, designating the manufacturer, month and year made, serial and heat numbers, other symbols for type of wheel, multiple wear or one wear, and occasionally other markings, such as carbon content of heat, etc.

Web holes are in most cases omitted. However, equipment is provided, in case these are required, to punch either two, four, six, or eight equally spaced holes of $1\frac{1}{4}$ in. diameter, which are later reamed to $1\frac{3}{4}$ in. diameter or larger. This can be performed by transferring the wheel to a 600-ton press, prior to coning.

The wheel is now placed in a coning press for dishing, which deforms the web from a plane disc shape to a deformed cone shape. This is performed in a 2000-ton press, as shown in Figure 13. The wheel is transferred with a jib crane from the buggy to the bottom disc. The bottom jack is moved in, pressure applied to the center ram and then the crosshead, to perform the coning operation. The top die exerts pressure on the inside face of the rim and hub only. The lower die supports the wheel, both at the outside face of the hub and at the outside tread. After releasing the pressure, the wedge blocks are rotated slightly and the operation repeated, in order to remove any traces of block marks on the tread, and give the wheel true rotundity. The lower jack of the press is then moved out, to permit transfer of the wheel with a jib crane to the loading mechanism of the adjacent equalizing furnace.

After coning, the wheels are air cooled through the critical range, while suspended on an overhead conveyor, on their way to the equalizing furnace. On their travel through this furnace the wheels are maintained at a temperature slightly below 1000 F for 4 to 5 hours to equalize any temperature difference between web and heavier sections. The wheel temperature is then gradually reduced for 3 to 4 hours, and upon leaving the furnace the wheels are removed from the conveyor, and charged into unfired slow cooling pits for approximately 16 hours, until they cool below 300 F. This process assures low residual stresses and minimum failure from internal rupture. The equalizing furnace, shown in Figure 14, is a double strand suspended hook overhead conveyor type furnace of U-shape construction, including a discharge tunnel. The furnace is of sufficient length to take the entire product rolled on the mill for an 8 hour period. The overhead conveyor construction permits adequate gas travel around the entire wheel, and with the aid of pyrometers and automatic gas valves maintains close control over furnace temperature. The slow cooling pits are of insulated refractory construction, in which the wheels are piled horizontally until full, and then covered. This close control over equalizing and slow cooling, it is felt, eliminates the occurrence of internal fractures in the rim and hub of the wheel.

Heat treatment of wheels, if specified, consists of treatment of the rim only, or of the entire wheel. For

Figure 16 — A vertical machine for turning car wheels is shown in this photograph.

Figure 15 — Rim toughened wheels are quenched by inserting the wheel only far enough in the bath to cover the rim and rotating it at a definite speed.

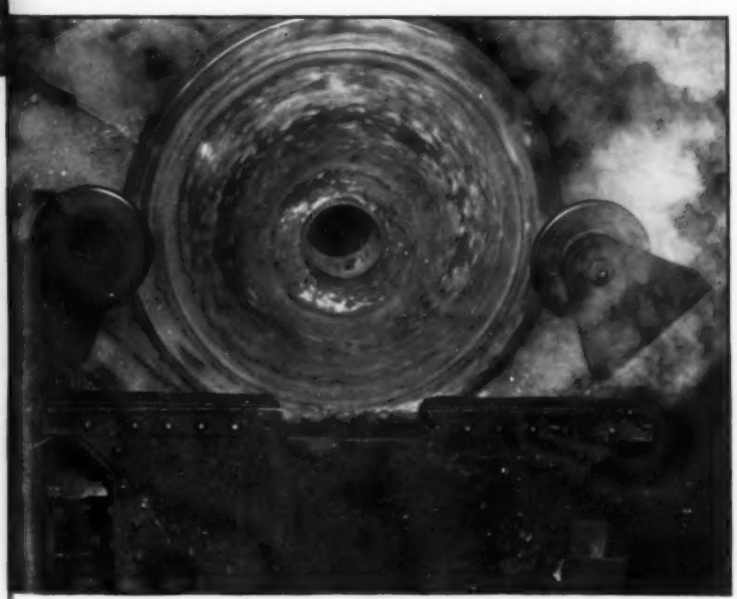


Figure 17 — Shown here is the rough boring operation on car wheels.

rim toughening, the wheels are charged flat into a continuous walking beam furnace, and brought gradually from room temperature to a point above the critical temperature. Upon removal from the furnace at approximately 1500 F, each wheel is placed singly in a quenching machine in upright position, as shown in Figure 15, and rotated at a uniform rate for a predetermined period with the rim submerged in water, and water sprays acting against the part of tread not submerged. The wheels are then charged into a similar type of furnace, for tempering or drawing at approximately 850 F for removal of internal stresses in web, hub, and rim, and to obtain the required hardness in the wearing zone of the rim, after which they are placed in slow cooling pits for controlled cooling to below 300 F. This treatment increases the hardness of rim up to a range from 277 to 363 BHN, as may be specified according to class and service requirements. Service tests have shown the superiority of rim toughened wheels over oil quenched product for resistance to thermal cracking due to brake shoe action.

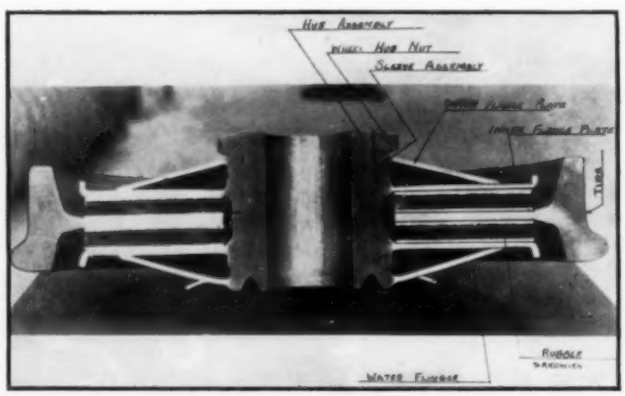
For oil quenching, the wheels are heated in the above described manner, and then completely submerged in oil and rotated for a predetermined period suspended from a post type crane. The wheels are then tempered to the required specified range of hardness for rim and hub, and controlled cooled to below 300 F. The hub can be maintained soft during the oil quenching, by previously clamping two discs together on the hub faces, to keep the oil from coming in contact with the bore or faces of the hub, while the wheel is submerged in a vertical position.

Thorough inspection follows the material throughout the various processing steps from open hearth furnaces to the finished product in the wheel plant; however, all one wear wheels that are rolled to finish, are given a rigid inspection before machining. This covers surface defects, rotundity of tread, position of hub, and size as measured on the circumference of tread in standard tape sizes for the industry. The defects, tape size, and order number are plainly marked on each wheel. The surface defects are usually light, such as overfills, underfills, slivers, and scale pits, and may be removed by machining. On rolled to finish wheels that are found to be satisfactory, the remaining operation consists of transferring the wheels to the finishing shop for rough boring and facing of hub only. Those wheels, requiring corrective repair work to remove surface defects, are again given a final inspection after completion of machining.

Machine finished wheels, which include all multiple wear wheels and some one wear wheels if specified, after controlled cooling, or after heat treatment, are transferred directly to the finishing shop for machining of tread and flange, and rough boring and facing the hubs. In Figure 16, the wheel turning operation on a vertical car wheel machine may be seen. Figure 17 shows the rough boring operation. The machining may include items which are not covered by standard specifications· for instance, machining limit-of-wear groove in rim, or machining underside of rim, web, or hub to improve balance or reduce weight, or drilling holes in web or reaming those punched in, counterboring hub faces, beveling or machining fillets on outside edges of hub faces, turning stress-relief grooves in hub faces, finishing hub faces to tolerances closer than standard, boring hub to exact finish dimensions, etc.

After machining, the wheels are given a rigid final inspection for thickness and height of flange, tape size and dimensions of rim, rotundity, thickness of web, size and position of hub, diameter and eccentricity of bore, and soundness of material. The wheels passing inspec-

Figure 18 — The standard PCC resilient wheel is a patented wheel.



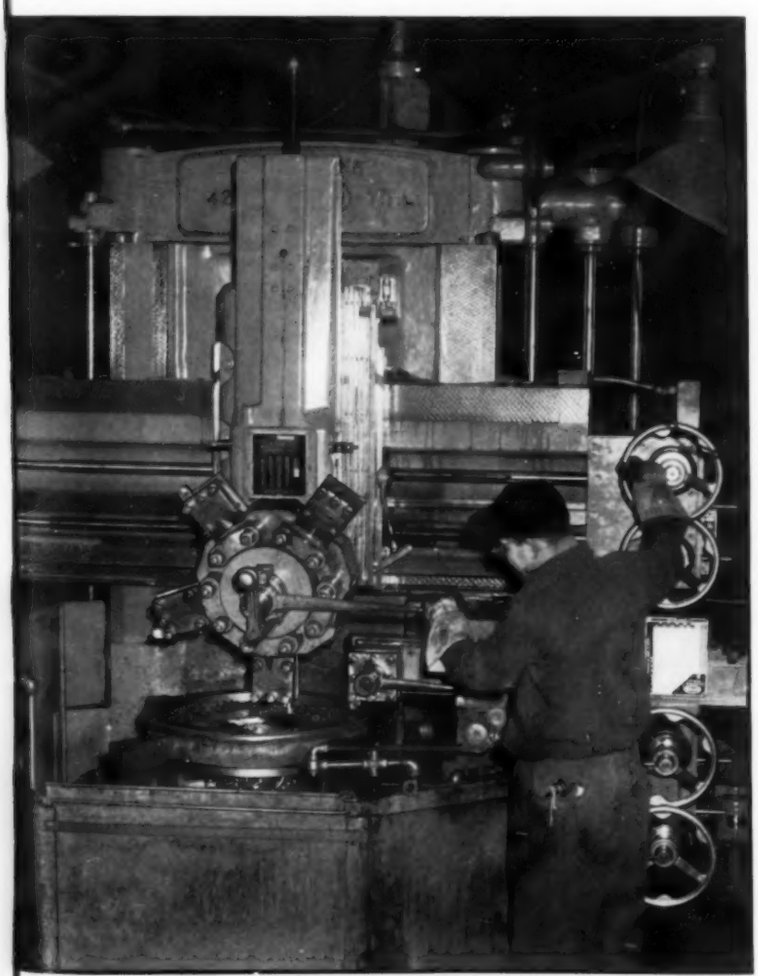
tion are stenciled with tape size and markings requested by customer, mated as to tape size, and shipped in pairs. Facilities are provided for the inspector representing the customer to assure himself that the material is being finished in accordance with specifications prior to shipment.

FORGED CIRCULAR SECTIONS

Some wheels, due to limitations of equipment as to shape or size, are all-forged, and are not rolled. This includes small industrial wheels, very large wheels, and special types, such as mine locomotive and mine car wheels, crane track wheels, sheave wheels, flywheels and piston heads, industrial wheels for light cars and switching engines, gear blanks, street car wheels, including resilient wheel tires, and miscellaneous circular sections ranging from plain discs up to intricate sections. The weight may vary from under 100 pounds up to approximately 3500 pounds.

The resilient wheel, as previously mentioned, is a patented wheel for street car service, developed by the Transit Research Corporation, with rights assigned to Carnegie-Illinois Steel Corporation for making the

Figure 19 — A vertical turning lathe is used for machining resilient wheel tires.



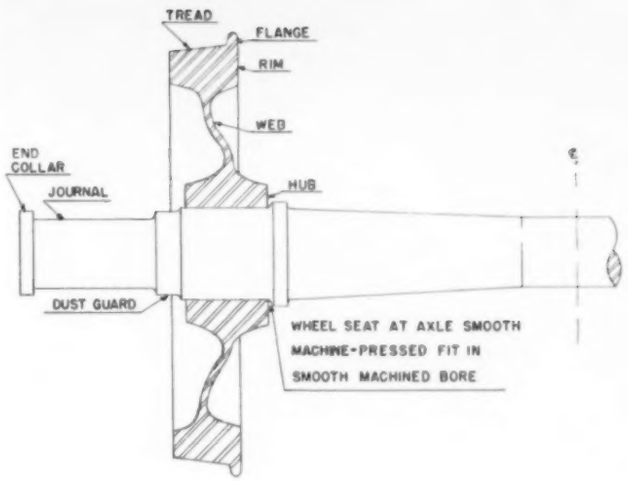


Figure 20 — The component parts of a railroad wheel and axle are illustrated by this sketch.

wrought steel type, and to the National Malleable and Steel Castings Company for the corresponding wheel with a cast steel rim. The standard President's Conference Committee resilient wheel, shown in Figure 18, consists of a rim (or so-called tire), the web plate of which is sandwiched between discs of rubber and flange plates for aligning with the hub assembly. The rims are either forged or rolled at the McKees Rocks plant, dependent upon their design, and shipped to the Lorain division at Johnstown, Pennsylvania, for final assembly of the resilient wheels.

After careful descaling of the wheel blocks of 9, 15, 17½, and sometimes 24 in. diameter, in a swinging chain type of descaler, they are forged on a 10,000-ton all-purpose press. The forged sections, after cooling below the critical range, are placed in slow cooling pits for controlled cooling to below 300 F. These circular shapes may be heat treated by rim toughening, or oil quenched and tempered, followed by controlled cooling, in a manner similar to rolled wheels. Forging alone will not produce the smooth finish obtainable by rolling, and therefore, all forged product requiring a smooth surface must be machined to finish; however, some sections for certain kinds of service are successfully forged to finished dimensions. All machined to finish wheels are turned in standard boring mills, and specially designed machines are used for turning tread and flange, and for boring and facing of hubs. Figure 19 shows a vertical turning lathe with turret and side heads, used on resilient wheel tires for rough turning of tread, rim, and web, and removing center portion.

AXLES

Homestead produces axles ranging from 400 pounds up to approximately 5000 pounds each, including those for locomotives, passenger cars, freight cars, engine tenders, street cars, etc. We will limit the process description to the manufacture of a standard friction bearing axle.

Figure 21 — Steam hammers are used to forge the axles.

The parts of an axle, as shown in Figure 20, consist of the end collar, journal, dust guard, wheel seat, inside collar, and center. They are generally made of carbon steel, with an analysis range of:

C	0.40 to 0.55 per cent
Mn	0.60 to 0.90 per cent
P	0.050 max per cent
S	0.050 max per cent
Si	0.15 min per cent

The large axle blooms are square and are rolled on a 44 in. blooming mill at the Homestead Works, while the smaller sizes are further rolled into rounds on a 36 in. roughing mill. These are conditioned and shipped to the axle plant at McKees Rocks, Pennsylvania. The rounds are reheated in a continuous type furnace to forging temperature, and forged under steam hammers into axles, as shown in Figure 21. The journal and end collar on one end of axle are forged first, and then the center section is forged toward the end of axle and wheel seat. The forging is then completed in a similar manner on the other end of axle. Axles are straightened in a gag press while above 950 F, and then controlled cooled in slow cooling pits.

If heat treating is desired, this is performed in one of the four car bottom type furnaces, one water quench tank, or an oil quench tank. Heat treatment consists of either annealing, normalizing, or quenching and tempering to meet physical properties covered by specifications.

Certain large axles are bored from end to end to remove segregation, to lighten the axle with minimum reduction in strength, and give greater uniformity of quench in heat treatment.

The axles are cut to length, centered, and then machined to suit customer's requirements, which may cover rough turning wheel seat and journal, rough turning all over, finish turning wheel seat and journal, or finish turning all over. The end collar, journal, and dust guard can be burnished or ground, as required for certain types of axles. Figure 22 shows an axle turning lathe machining a locomotive driving axle.

The finished axles, before shipment are closely inspected for size, defects, and eccentricity, and a representative number of axles are selected for impact (drop) test, and physical laboratory tests. Careful control over manufacturing practices and testing procedure is enforced to minimize any possible causes for failure.

Figure 22 — After forging, the axles are turned in the lathe.

MOUNTED WHEEL SETS

A satisfactory wheel and axle assembly requires that both wheels mounted on one axle must be mates, of diameter limitations within the tolerance for tape size. The wheels are finished bored to a size slightly smaller than the wheel seat of the axle to be used. Each wheel is then forced onto the wheel seat by a hydraulic operated wheel mounting press. The mounting pressures must be within certain limiting ranges, to insure a tight fit and avoid damaging the wheel or axle. The distance between wheels must be accurate, and within the allowable tolerances as specified by the Association of American Railroads.

LAYOUT OF PLANT EQUIPMENT

Referring to Figure 23, the wheel blocks, shipped from Homestead in gondola cars, are stocked in piles at the large West Yard area until needed. The blocks are then transferred in mill gondola cars to the main mill building, where limited storage area is also available. The blocks are loaded in boxes and carried to the preheating furnace. From here the material flow is in a direct line to heating furnaces, first forging press, first reheating furnaces, second forging and hub punch presses, second reheating furnace, wheel rolling mill, stamping machine, coning press, continuous equalizing furnace, and to adjacent slow cooling pits. The power house is centrally located, and contains all hydraulic pumping equipment for presses, electrical substation, motor generator sets, and other electrical equipment for serving both wheel plant and axle plant. Wheels and circular sections to be heat treated are received in gondola cars on the track adjacent to the heat treating building. The heat treated product is handled by wheel

rollers, or by lift truck, to the adjacent wheel finishing area or circular section finishing shop. The wheel finishing shop, inspection, storage, and shipping areas are all located in close proximity to one another. The finished wheels and mounted wheel sets are loaded in gondola cars in the shipping building, and shipped to customer. The machine shop is located with easy access from either wheel plant or axle plant. In addition to finishing and mounting wheels and axles, the machine shop also machines all dies used for forging presses, and rolls required for wheel mill.

The wheel blocks for circular sections are charged in the heating furnaces located at west end of main mill building, forged in the adjacent 10,000-ton press, and

SERVICE AND SAFETY

The service mileage of one-wear wrought steel wheels is estimated conservatively at 150,000 to 170,000 miles when used on 50 and 70-ton freight cars, which is equivalent to 15 to 17 years' service with present day car usage of around 10,000 miles per year. The estimated life of one wear wheels was based on actual test results on a series of freight cars, and revealed that the first period of wear averaged over 150,000 miles. The one wear wheel was designed and put in service in 1925. With more than 20 years' experience under railroad equipment, the estimate has proved conservative.

A study was conducted in 1935 on the service results

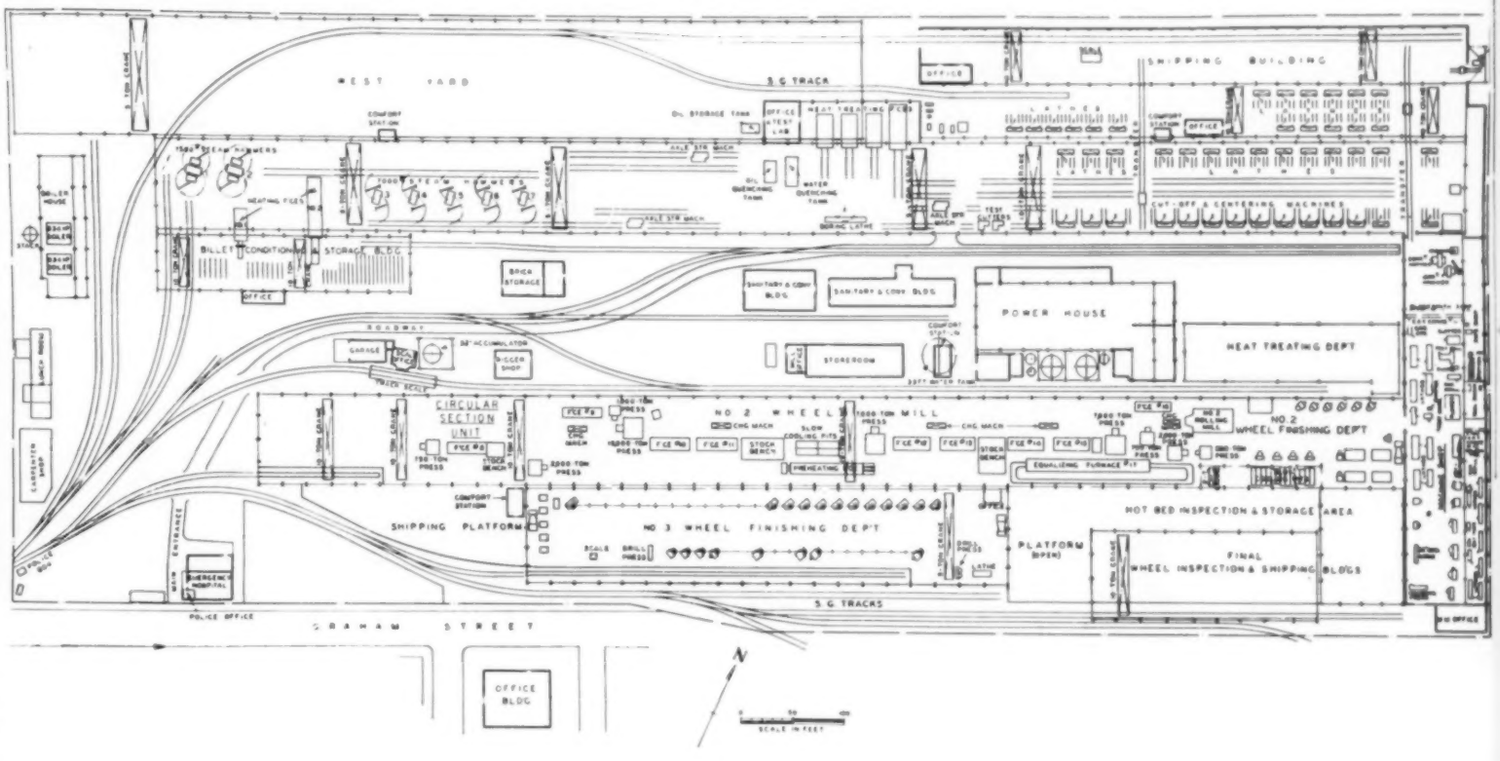


Figure 23 — Layout of wheel and axle plant facilities of the wheel and axle division, Carnegie-Illinois Steel Corporation, Homestead District Works.

the product controlled cooled in nearby slow cooling pits. The adjoining building houses machine tools for finishing, and provides shipping space.

The axle rounds, received from Homestead, are unloaded from gondola cars in the billet storage building. These rounds are charged directly into the roll-down continuous type heating furnaces. The material flow from here is in a direct line to steam hammers, axle straightening machines, and slow cooling pits. The boiler house is located adjacent to steam hammers. Heat treating furnaces and quench tanks are adjacent to the straightening machines. This is followed by the cut-off and centering machines, and the turning and finishing machines. The shipping building is located adjacent thereto.

from 202 freight cars of 70-ton capacity. These cars had been equipped with multiple wear wheels and placed in service in 1922. The wheels were untreated and had a nominal 2½ in. rim thickness. An estimate of the total life of the wheels was 37.3 years.

The Carnegie wrought steel wheel is processed to meet all the present day safety standards and load requirements, along with the increasing speeds required in locomotive, passenger car, freight car, and electric service.

In conclusion it may be emphasized that research in our laboratories and improvements in our processing and equipment will continue to assure a product satisfying the continuously progressing demands of the transportation industry.

DISCUSSION

PRESENTED BY

LOUIS MOSES, Superintendent, Rail Mill and Roll Department, Bethlehem Steel Company, Sparrows Point, Maryland

W. A. ASHTON, Superintendent, Wheel and Axle Division, Carnegie-Illinois Steel Corporation, Munhall, Pennsylvania

L. J. GOULD, Chief Engineer of Construction, Bethlehem Steel Company, Bethlehem, Pennsylvania

WALLACE E. SHISSLER, Plant Engineer, Standard Steel Works Division, The Baldwin Locomotive Works, Burnham, Pennsylvania.

Louis Moses: A cylindrical blank is formed into the compound, cross-sectional shape of a circular wheel whose rim diameter is several times greater than the blank. Perhaps the piercing of a seamless tube is the closest comparison to the crucial work which good steel will withstand in forming it into useful products and with the quality of the material improved by such work.

The relatively heavy hub, thin web and heavy rim offers an interesting study of metal flow. During the several stages of reducing the area of an ingot to that of a shape or bar, there are definite factors governing flow. Such bars in a rolling mill (excepting continuous mills) are free at their ends, with the cross sections of the various stages the major contributing factors in creating the desired shape. In wrought car wheel manufacture from a blank, this is not wholly the case because elongation, as must be the case when rolling the web and expanding the rim to diameter, is opposed by the confining influence of the heavy rim. This sets up reacting forces to elongation, which works the steel and creates a true forging action.

From discussion with those who know the trade it has been gathered that conflict exists in certain phases of the service imposed on wheels. This is somewhat analogous to that of the armor plate and the projectile. When one becomes ascendent the other is improved to meet the new condition. When this is accomplished it nullifies the superiority of the first and the matter is begun all over again. Wheel treads must withstand the friction of brakes but brake material must be adequate for its function. Sudden braking is a condition of service and wheel treads become flat from sliding on the rails when locked, a condition sought to be avoided by maximum resistance to such wear. Again, rails must withstand such sliding with a minimum of damage. Wheel treads become very hot at times and must nevertheless to a reasonable extent be capable of withstanding such heat shock.

The flange thickness on railroad car and locomotive wheels has always presented a problem. It can be imagined that many an engineer wishes that this member could be increased in thickness. Similarly, the wheel manufacturer must build quality into his steel to provide requisite strength to withstand the force imposed by a heavy car pulling against the high rail of a curved track. But it requires but little thought to realize that flanges cannot be thickened because thereby every frog and switch opening in the tracks of the United States, Canada and Mexico would require opening up.

It is noted that controlled cooling is introduced into the process. The meaning of this may have escaped the attention of some of those present. This is not the place, nor could I adequately discuss the matter, but the process of controlled cooling has practically eliminated a former hazard to railroad safety as brought about through heavier wheel loads and train speeds. Manufacturers of steel, rolled as well as cast, are keenly aware of the possible development of shatter cracks and flaking in large cross-sections. It has been found that slow cooling corrects such a tendency which, under severe service, might otherwise develop into transverse fissures.

I have but one question. Are blanks surface reconditioned and if so, is it done by flame scarfing or by chipping?

W. A. Ashton: The rolled logs are surface conditioned, if necessary, with chipping hammers, and then the small center portion remaining after hot nicking or cold slicing is fractured to produce the individual blocks.

L. J. Gould: Do you make one nick at a time?

W. A. Ashton: We hot nick one block at a time. In cold nicking, six nicks are made at a time on a cut-off machine, equipped with six tools on each side.

L. J. Gould: What kind of material do you make the nicking plates out of?

W. A. Ashton: The knives are made of SAE 4340 type universal mill plate, flame cut, heat treated and oil quenched to give hardness of 55-60 Scleroscope, and then machined. Favorable results have been obtained by the use of stellite on the cutting surface of the blades.

L. J. Gould: There is one other question, and that is on die life. I saw nothing in the picture to show any means of cooling or flushing the dies. I suppose there is such equipment?

W. A. Ashton: Yes, we have sprays, and also pipes on both sides of press. The dies are flushed and sprayed after each operation. Die life is a factor that is given close consideration, and to maintain satisfactory life we are continuously experimenting. Dies are normally made from chrome nickel steel.

Wallace E. Shissler: On your one wear wheels, in classifying your slugs or chunks, within what weight tolerances do you classify them?

W. A. Ashton: I would like to have within 10 pounds over and 5 pounds under on the one wear wheel.

Wallace E. Shissler: Referring to Figure 17 where you showed the picture of the boring operation, do you bore after you have turned the flange?

W. A. Ashton: On any wheel which is turned, we bore after the turning. On one wear wheels which are rolled to finish, boring is the only machining operation.

Silica and Fire Clay Refractories

FOR STEEL PLANT FURNACES

. . . . super-duty silica brick should give 15-25 per cent increased life in sprung roofs . . . . better life is due to higher melting point, higher refractoriness, and high mechanical strength . . . .

By C. A. BRASHARES, District Sales Manager
Harbison-Walker Refractories Company
Birmingham, Alabama

▲ FOR years silica brick have been an essential steel plant refractory, especially for construction of open-hearth roofs and walls. Their high mechanical strength at open-hearth temperatures, their unique expansion characteristics, and their high refractoriness make them invaluable for this service.

Until recently, the conventional silica brick met all the requirements for silica refractories and they will continue to be used to the extent of many millions annually.

During the past few years, considerable attention has been paid to the desirable effects of a low content of impurities in the silica brick. The super-duty silica brick recently developed represent the purest commercial silica refractory produced, having a total content of alumina, titania, and alkalies of 0.5 per cent maximum, as contrasted with a range of 0.9 to 1.4 per cent for conventional silica brick.

The difference in composition may seem relatively small even to the regular user of the super-duty silica brick. However, its importance may be illustrated by referring to calculations of the theoretical equilibrium melting behavior of silica brick of the conventional and super-duty types:

TABLE I

Equilibrium Melting Behavior of Silica Brick (Based on phase rule diagram: CaO-Al_2O_3-SiO_2)

Per cent of Liquid formed	Silica brick conventional type	Silica brick super-duty
10	1400 C (2250 F)	1670 C (3040 F)
20	1610 C (2930 F)	1690 C (3070 F)
30	1650 C (3000 F)	1695 C (3085 F)
100 (complete melting)	1700 C (3090 F)	1715 C (3120 F)

In various meetings of open-hearth operators, the service life secured from super-duty silica brick in open-hearth roofs has been discussed in rather complete detail and significant improvements have been reported. It might be well to mention some of the comments concerning their performance. One comment has been that the super-duty silica brick do not glaze over and bond together as conventional silica brick do. Actually, however, super-duty brick do glaze over, and it is only a matter of securing a higher temperature to effect a comparable degree of glazing. Since the open-hearth operator is continuously striving for high operating temperatures, this should be a desirable feature of the super-duty brick. In furnaces where super-duty brick do not glaze over sufficiently to facilitate hot patching, one of the usual procedures is to use a super-duty silica cement in installing the roofs. The properties of these cements will be touched upon a little later, but for the time being suffice is to say that these cements provide a highly refractory bond for the roof brick, either when applied as a grout or used as a mortar.

The super-duty silica brick may be adapted to open-hearth roofs without any other precautions than those followed in good practice in the use of the conventional silica brick. This is a point which may be of considerable interest in the final measuring of improvements over present roof refractories.

In connection with suspended roof brick, some work now being done by the copper companies may be of interest. These companies employ chemically-bonded basic brick in suspended construction. However, at certain points in the roof campaign, there is good promise of the economical use of silica brick for hot patching. These brick are inserted into the roof in steel casings, and are in effect metal-encased silica brick. They are used together with basic brick, and due to their lower cost, make for some very substantial economies in the improved balancing of roof life.

An interesting silica refractory which has been in use for a number of years is the lightweight insulating silica

Presented before AISE, Detroit District Section Meeting, April 12, 1948

brick, which is approximately half as heavy as the conventional silica brick. In the glass industry, it has had ready acceptance for insulation of a number of parts of the glass tank superstructure. However, in the open-hearth roof, since operating temperatures are so near the melting point of silica brick, the use of this lightweight silica brick for insulating purposes has not been extensive. Yet, with closer pyrometric control and the increased use of super-duty silica brick, this lightweight silica brick will possibly become of greater interest. Then, too, as work may be done on the insulation of basic roof, a lightweight silica refractory offers advantage over the alumina-silica type of lightweight refractories, because of its higher reaction temperature with magnesite or chrome-magnesite brick.

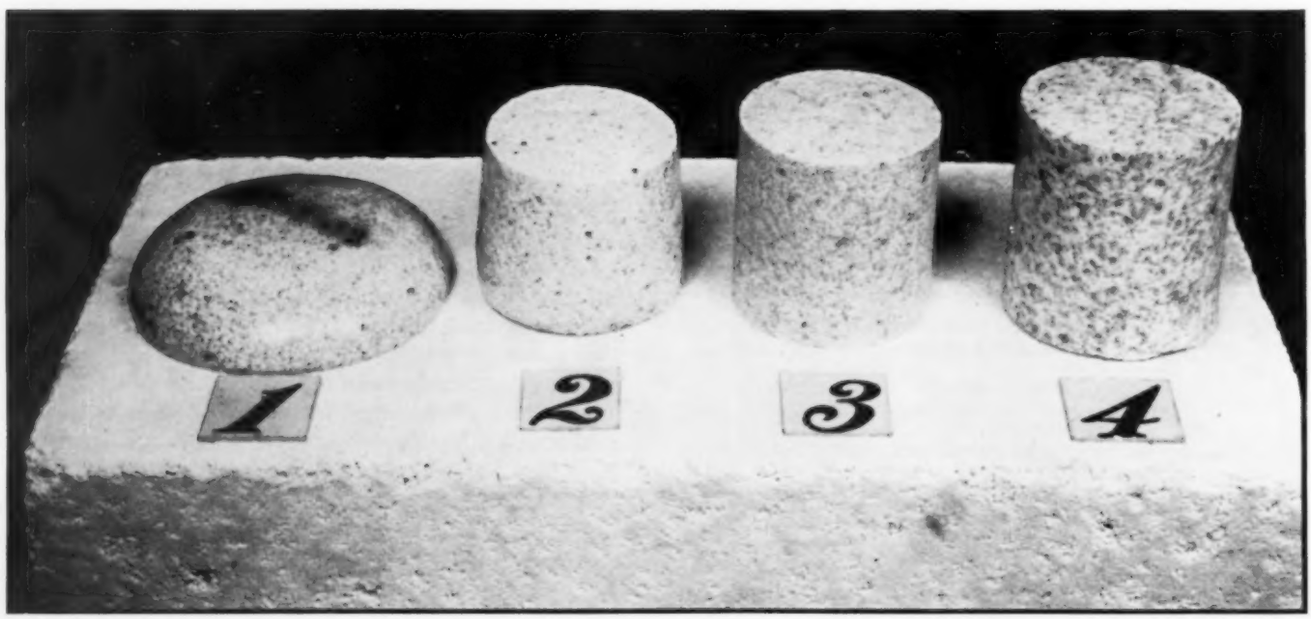
Mention was previously made of super-duty silica mortar. To properly fulfill its functions, such a mortar should be comparable in refractoriness to super-duty silica brick. Furthermore, it is desirable that the mortar have a composition corresponding to that of super-duty silica brick, since this eliminates many possibilities of slag combinations between the dusts and fumes in the furnace gases and the components of the mortar. With the real advantages of low-alumina content in the roof brick, it is fortunate that mortar can be secured of equally low alumina content. One engineer, in outlining his thoughts on this subject, explained that to demonstrate the advantages of a split-roof test of super-duty silica brick, he insisted that the super-duty brick be laid up with a super-duty silica mortar. At the same time, he allowed the continuation of the regular practice for installing the conventional silica brick in the other half of the roof, which practice comprised the use of a silica clay of relatively lower refractoriness. He attributed the superior performance of the super-duty silica brick not only to their low alumina content, but also to freedom of fluxing at the joints. Figure 1 illustrates the relative resistance of several silica cements.

On the subject of fireclay refractories, we might first refer to some points in connection with blast furnace linings. A problem related to blast furnace refractories which has been recognized for a great many years is disintegration due to deposition of carbon. A great deal of work has been done in the study of this phenomenon and a reasonably good understanding of it has been attained.

Early investigators found that the carbon deposition which started such disintegration resulted from the action of carbon monoxide gas and that it began close to segregations of iron compounds in the brick. While use of fire clays free from iron impurities might at first appear desirable, fuller consideration indicated the necessity for other steps. This is especially true when the ready availability of iron compounds from the furnace charge is taken into account. In laboratory tests, extra hard firing of the blast furnace refractories in a controlled atmosphere was found to render the brick apparently immune to carbon monoxide disintegration. The test procedures developed would almost totally disintegrate a blast furnace brick of the regular burn, but have no noticeable effect with these extra hard-fired products. It is of particular interest to note that specially made test specimens containing clays of almost negligible iron oxide content, but not fired hard, could be disintegrated, while extra hard burned fireclay brick of considerably higher iron oxide content showed no disintegration whatever.

Many installations have been made of the high-fired blast furnace brick, and such inspections as have been possible after campaigns have failed to show disintegration. They may be used very advantageously from the mantle up, where disintegration generally causes the most difficulty, since the temperature at which it takes

Figure 1 — Effect of heat treatment at 2960 F on silica cements of various types. From left to right are shown commercial silica cements of progressively higher degrees of purity and refractoriness.



place most actively is closer to the working face of the brick toward the top of the furnace.

While the disintegrating effects of carbon deposition in the blast furnace have been given attention over the years, frequently equal attention has not always been given to this phenomenon in other furnaces. With highly-reducing gases, such as carbon monoxide or cracked hydro-carbon gases, possibility of disintegration due to carbon deposition should always be considered, especially where temperatures within the range of 700 to 1000 F can be expected. If furnace temperatures are higher, it should be remembered that as a result of the temperature drop through the furnace walls, the critical temperature zone for carbon deposition occurs somewhere in the refractories forming the structure. The extra hard-fired refractories should be considered where such conditions must be met. As to the insulating refractories, studies show that the high-fired lightweight insulating brick are immune to carbon monoxide disintegration in laboratory tests. The lightweight refractories of the 2600 F or 2800 F classes are for the most part very resistant to disintegration by carbon deposition from carbon monoxide or cracked hydro-carbons.

Observations of blast furnace linings, after campaigns have been completed, have shown sections of the bottom blocks nearest the salamander to have essentially zero porosity. With extremely low porosity attained in the blast furnace bottom block as installed, it would seem reasonable to expect greatly improved service from the refractories in the furnace bottom. A blast furnace refractory is now in the process of development which shows very much lower porosity than has ever been attained heretofore except by complete fusion.

The advantages of using a highly refractory clay mortar of high plasticity for laying blast furnace brick have become well recognized. The ease of handling clay of this type, with the tight joints it makes possible, is an important consideration, and of course the high-refractory qualities are most desirable. In the furnace tops, where the temperatures may never get sufficiently high to develop a ceramic set in fire clay, considerable advantage has been secured from the use of a good high temperature bonding mortar for installing the brick. The ready mixed high temperature bonding mortars with a high-alumina base serve well for this requirement. They develop an air-set and good strength merely upon drying; this strength is retained throughout the operating temperatures of this part of the furnace.

It may be well to touch briefly on the subject of general mill brick. Frequently, the great importance of his other duties causes the steel plant operator to be content to use almost anything in the way of brick for this service. However, the properties of fireclay brick vary so widely even for brick within the same price range, that attention to securing brick most suitable for each application is well merited.

Take for example the property of hardness. There are many applications in the steel plant requiring mechanically strong and hard brick. The high-quality, buff colored fireclay brick manufactured especially for acid-proof constructions may frequently be employed to advantage in refractory structures where hardness is required. These brick are much harder than those of the high-duty class. Their refractory qualities are such that, with continuous operation, they may be used at temperatures of approximately 2300 to 2400 F, or slightly higher.

Of the high-duty fireclay brick, the hard burned vacuum power pressed and extruded products are well known for their hardness and strength. They are not quite as hard as the acid-proof brick, but may be used at somewhat higher temperatures.

The high-fired super-duty fireclay brick also are hard and mechanically strong, and have the additional advantage for many applications of being tough and resistant to mechanical shock. With their higher refractoriness, they are used at temperatures above those at which high-duty brick may be safely employed.

Spalling of one type or another is a frequent cause of destruction of refractories. While there are several types of spalling, one of the most important is that due to thermal shock. Power pressed high-duty fireclay brick are well known for their excellent resistance to temperature shock. In recent years, super-duty fireclay brick have been used to an increasing extent where the greatest resistance to spalling is required. The high-fired, super-duty fireclay brick are most resistant to temperature shock. Taking into account their hardness and their resistance to thermal spalling, it is very likely that the use of these brick will continue to increase in steel plant operations. They are especially well established for use in metal mixers and heating furnaces.

Another important property of refractories is their load-bearing capacity. Proper attention to this can frequently save a great deal in maintenance. Where the refractory must sustain appreciable pressure at a temperature of approximately 2400 F or slightly lower, the siliceous type of fireclay brick has been noted for its load-bearing abilities. Siliceous Pennsylvania and New Jersey brick were most prominent in the field for this purpose. More recently, the high-quality Alabama and Texas brick with outstanding load-bearing properties have become used to an increasing extent. While these brick do not have as high silica content as some others, they have comparable or even superior strength under load at high temperatures due to their extremely low content of impurities.

Where a substantial amount of insulation is applied or where the furnace temperatures are higher than siliceous fireclay brick will withstand, super-duty fireclay brick, especially those of the extra hard burn, provide the next step-up in load-bearing capacity at high temperatures. The outstanding properties of this class of refractories is due in no small part to their manufacture by the power press process. Accordingly, it is especially desirable to use the standard sizes and sizes adaptable to power pressing with this class of material. Above these super-duty brick in refractoriness, there are now available high-alumina refractories containing corundum which have unusual strength at high temperatures. Silica brick have remarkable resistance to load at high temperatures, as every steel plant operator knows.

DISCUSSION

PRESENTED BY

P. C. DODDS, Superintendent Masonry Steel Division, Ford Motor Company, Rouge Plant, Detroit, Michigan

C. A. BRASHARES, District Sales Manager, Harbison-Walker Refractories Company, Birmingham, Alabama

A. E. REINHARD, Great Lakes Steel Corporation, Ecorse, Michigan

G. H. YOXALL, Great Lakes Steel Corporation, Ecorse, Michigan

F. G. HECK, E. S. Lavino and Company, Philadelphia, Pennsylvania

H. F. LESSO, Open Hearth Control Metallurgist, Great Lakes Steel Corporation, Ecorse, Michigan

W. H. COLLISON, Coke Plant Superintendent, Great Lakes Steel Corporation, Ecorse, Michigan

HOWARD JONES, Babcock and Wilcox Company, Detroit, Michigan

Preston C. Dodds: At the Ford Motor Company we are planning to go 100 per cent on super-duty silica brick in the roofs of open hearth furnaces, I am speaking with authority because management is telling me to put them on. We have had a little experience with them here. I have had experience in two other plants with this brick, and they are going to do the job for us for just the reason that Mr. Brashares has told us. I would like to ask a question while I am on my feet. Do you think by grouting either a conventional roof or a super-duty silica roof that we accomplish more?

C. A. Brashares: I think you do. There has been the comment that super-duty silica brick do not glaze over in the manner of conventional silica brick. This was mentioned previously, but I think we might enlarge a little on the subject. As one operator put it, "the super-duty brick unravel when a hole develops in the roof." I believe this means of expressing the condition is clear, but might add that when the brick are knocked out for a patch in the roof, there is a tendency for super-duty silica brick which have been laid dry to come out in relatively large sections, due frequently to a lack of bond between the brick which a glazed interior surface may provide. Since roof brick which will stand higher temperatures before dripping are desired by the open hearth operator, and glazing is in reality incipient dripping, then where glazing is not secured it follows there is some real advantage in the use of a high quality silica mortar for grouting or laying the silica roof brick. In the case of a mortar of low refractoriness, it is not just a matter of the possible melting of the mortar and draining from the brick joints. Rather it comes down to a low refractory mortar even fluxing the adjoining brick. In the plastic state, the mortar is also more reactive with the iron oxide and other fluxing constituents of the furnace gases.

Preston C. Dodds: My thought on this subject is purely from the standpoint of an installer of refractories, and I contend that a flame coming up and through any openings between the brickwork, will carry enough iron oxide with it to push the alumina on up and cause running, that is the reason I have always grouted the roofs even with a low grade of silica cement. We are thinking along the lines that you have recommended tonight on using a super-duty silica cement, especially with our super-duty silica brick.

C. A. Brashares: In furnaces where extremely corrosive fumes are present, as for example in glass tanks producing borosilicate or the "pyrex" type of glass, maximum tightness of the silica roofs has been proved definitely advantageous. Some of these roofs are grouted and others laid up with a relatively heavy troweled joint of super-duty silica mortar.

A. E. Reinhard: We have used considerable super-duty silica brick, but they have all been on suspended roofs, and we have never used any on the sprung arch roof. Of course, we get better life on the suspended roofs with a super-duty silica brick, as we would be expected to, but how much is because of the super-duty silica brick, that we do not know. In fact, that is a question that I would like to ask, in other places, where they have a comparison between the two, what do they show as the difference between the two roofs, or in other words, in the sprung roof what improvement has super-duty silica brick shown over the regular silica brick?

C. A. Brashares: I would say of the order of 15 to maybe 25 per cent increased life with the super-duty brick.

G. H. Yoxall: Would you say that a super-duty brick has a tendency to be more straight and even than a low-grade brick? Using a rib course you often find that 18 in. rib courses have a tendency to have a bow in the brick itself. Now, your super-duty brick, would that help that in any way?

C. A. Brashares: If conventional and super-duty silica brick are manufactured by the same process, one would not tend to be of better or worse workmanship than the other. However, most super-duty silica brick, particularly for open hearth roofs have been made by the power press process. If these then were compared as to workmanship with hand made or gravity machine made conventional silica brick, the super-duty brick would be the better in workmanship.

F. G. Heck: Have you had any experience to indicate the comparison of the super-duty silica brick in sprung versus suspended open hearth construction?

Ray Over: I would like to think of one figure that was very nice at Ford's, but that was not average, I believe it was 323 heats on one roof.

E. H. Patrick: It was 202 heats without a patch and then a minor repair was done over the taphole when a much larger roof patch should have been put on, but with many small roof patches and too much lost time, we ran to 303 heats before the furnace was taken off the line.

C. A. Brashares: That compares roughly with what figure for the sprung?

Ray Over: Probably 178, or something like that. Incidentally, as a matter of interest, we did get our best results from silica brick laid up in high temperature

silica mortar; when roofs were dry, they did not do nearly as well.

H. F. Lesso: You speak of migratory characteristic of alumina being the principal cause of silica brick failure, what about Dr. Sosman's theory of the capillary action of iron oxide as being the principal cause for silica brick failure?

C. A. Brashares: Iron oxide attack is unquestionably a principal factor in the consumption of silica brick in an open hearth roof. Possibly an explanation of the comparative resistances of super-duty silica brick and conventional silica to iron oxide attack may be in the higher silica content of the former. We do know that silica brick resist iron oxide attack at high temperatures better than fireclay brick. The outstanding performance of silica brick in iron cupola melting zones is one illustration. Carrying this reasoning further, it seems we could expect the low alumina and high silica content of the super-duty silica brick to give improved resistance as compared to the conventional silica brick.

W. H. Collison: You have touched upon the super-duty silica brick. How does that compare with the silica brick ordinarily used in coke ovens?

C. A. Brashares: In the oven walls, the silica brick may well contain the percentage of alumina shown by conventional silica brick. This tends to increase their toughness. To the best of my knowledge, super-duty silica brick have not been used to date in by-product coke ovens.

W. H. Collison: Do you have any opinion or data on the merits of hand-formed shapes versus machine-made shapes for coke oven construction?

C. A. Brashares: The machine-made brick are generally lower in porosity than the hand-formed. Recently, we have been studying another property of refractories, namely: permeability. Porosity figures have not been particularly satisfactory for indicating density characteristics of refractories because they did not show the magnitude of individual pores or more important how the pores of a given refractory were connected. The latter is of interest in connection with penetration of contamination bearing gases in the furnaces. As a rule, power pressed brick have lower permeability than hand-made. Curiously, our tests have shown super-duty silica brick to have far lower permeability than conventional silica brick. In fact the super-duty silica brick have permeabilities in the range of a fairly dense fireclay brick. We realize this may also contribute to the exceptional service they have given in some furnaces.

W. H. Collison: Do you have any data in any way which would indicate which type of brick is more resistant to spalling due to stresses from the coking of pressure developing coals?

C. A. Brashares: No satisfactory test method has been developed to date for testing the spalling resistance of silica brick.

H. F. Lesso: Investigators have determined that silica refractories in the initial stages of service develop a film of micro-amorphous silica. What significance does this amorphous silica have in the service life of silica refractory?

C. A. Brashares: I would expect that pure silica would tend to protect the brick. In the illustration of the reheated super-duty silica brick the front section is often referred to as the "cristobalite" section.

H. F. Lesso: Does that suggest that being the various crystallographic modifications of silica having various stability temperatures (alpha and beta quartz stable up to 870 C; tridymite 1470 C and cristobalite 1870 C) the firing range is directed toward the cristobalite pattern in the finished products?

C. A. Brashares: Yes.

W. H. Collison: You have indicated that the best brick for blast furnace (in walls) would be a hard burning brick to resist the carbon monoxide. Now, how would you describe the type of brick that would be best for hearth and bosh wear?

C. A. Brashares: A brick of maximum density would have substantial advantage. Since bottom brick after long years of service may show almost zero porosity, there would seem merit in the use of bottom brick of lowest practicable porosity. While many specifications have been written for hearth and bosh refractories, I believe the most important qualities should be high refractoriness, high density or possibly better low permeability and adequate mechanical strength.

Howard Jones: You were talking about hard burning blast furnace brick, could you say, without divulging any secrets, about what temperature you burn those hard furnace, blast furnace, brick?

C. A. Brashares: We refer to the temperature in terms of pyrometric cones, and the temperature required is something like Cone 18, or above, and Cone 18 refers to 2714.

WANTED!

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CHROMIUM PLATING IN

. . . . chromium plating has developed into an effective tool in the steel plant maintenance shop . . . . the high speed of deposition developed by the author has led to major economies in the plating operation . . . .

▲ THE application of chromium plating for maintenance is part of the field of chromium plating for engineering use. This type of chromium plating permits the improvement of the abrasion resistant characteristics of machine elements and the reclamation of worn or mis-machined parts. There is a distinct difference between chromium plating for engineering use and that customarily applied as a decorative finish, for example, on automobile hardware. Decorative chromium plating is applied in thicknesses of the order of 10 millionths of an inch while in chromium plating for engineering use on machined parts, thicknesses of from two to seventy-five thousandths of an inch are entirely feasible. The technique of the application of chromium differs fundamentally in the two cases. For engineering use it is customary and best to apply the chromium directly on steel, while for decorative plating the chromium is applied over a polished surface of nickel plate that is present to provide corrosion resistance to the base metal.

In the early days of chromium plating, trouble was experienced in applying heavy electrodeposits in regard to their adhesion. This problem has been completely overcome and today it is possible to apply heavy chromium electrodeposits without fear of separation from the base metal, even under conditions of severe stress. Techniques satisfactory for obtaining excellent adherence between the chromium plate and the base steel are described in the ASTM recommended practice specification on chromium plating for engineering use. Unfortunately, some concerns in the field of commercial chromium plating that undertake to apply heavy deposits have never taken the trouble to learn the technique to obtain substantially perfect adherence, so it sometimes happens that an unsatisfactory application may result from this cause. Today, no potential application of chromium plating should be abandoned because of failure attributable to separation of the coating from the base metal; rather, a re-test is indicated using components the processing of which is under control.

In maintenance of operating equipment the presence of substantial benefit has been established through the application of relatively thick chromium deposits, particularly those produced by the newer high current density high temperature process that we have applied. By the use of chromium plating of many machine components a reduction in maintenance time demand has resulted from the longer life obtained. Also, some substantial decreases in the periodic attention required for the adjustment, for example, of packing glands have been noted. Improvement in the operating performance of both hydraulic and mechanical equipment has been obtained through chromium plating. The applications in which chromium plating have shown benefit range from gages through tools to light and heavy machine members, even up to those weighing 10 to 15 tons.

The properties of chromium plate that are of particular benefit in connection with its engineering use are its hardness, its low coefficient of friction and non-galling properties, and its great resistance to corrosion. These properties combine to make the coating resistant to wear and abrasion to a high degree. A quality of chromium plate that has been found quite satisfactory for engineering use has a hardness of approximately 825 Vickers Brinnell. Hardnesses above 1000 Brinnell have been obtained, but these are accompanied by an increased brittleness that limits its applicability in some cases. In connection with the wear of chromium plated surfaces, it has been noted that in many cases the wear of the opposing member is materially reduced, even though it is not chromium plated, because of the tendency of chromium to "wear smooth."

Any classification of the applications of chromium plating for maintenance purposes must be arbitrary, because of the number of different purposes where it has been found useful. Four such categories are: tools, gages, mis-machined parts, and wearing parts.

TOOLS

The life of certain tools may be prolonged by chromium plating their cutting edges. All tools are not benefited by chromium plating, in particular those subject to extra heavy duty. Tools that take only a light cut are usually benefited. The thickness of chromium normally applied to the cutting edges of tools is usually between 1 and 2 ten-thousandths inches. The successful application of chromium plate to cutting tools depends on a number of factors including the particular character of the chromium plate, and the conditions of service use of the particular tool. This accounts in substantial part for the wide diversions of reported results obtained in chromium plating tools. The chromium plating of cutting tools is more of an art than is gener-

Figure 1 — Photograph shows the unplated edge of a round nosed cutting tool.

MAINTENANCE PRACTICE

By DR. RICHARD M. WICK, Research Engineer
Bethlehem Steel Company
Bethlehem, Pennsylvania

ally appreciated, and repays amply the patience and extended study that it demands.

One factor that accounts, probably, for the majority of the difficulties encountered in plating cutting tools is the condition of the cutting edge after chromium plating. This is illustrated by Figures 1 to 3, inclusive. Figure 1 shows the unplated edge of a round nosed cutting tool. Figure 2 shows the condition of the edge after the application of the correct amount of chromium plate. Figure 3 shows a condition termed "beading" that results from the application of an excessive amount of chromium plate. Such a condition leads to a service life inferior to that of the unplated tool, while the correctly plated tool in many instances shows a greatly increased service life. In general, as much chromium should be applied as is possible without encountering the "beading" condition. For a given application, involving a particular plating process and operation, the amount of chromium plate that results in bead formation is experimentally determined, and the desired amount specified accordingly, e.g., 80 per cent of the determined amount for beading.

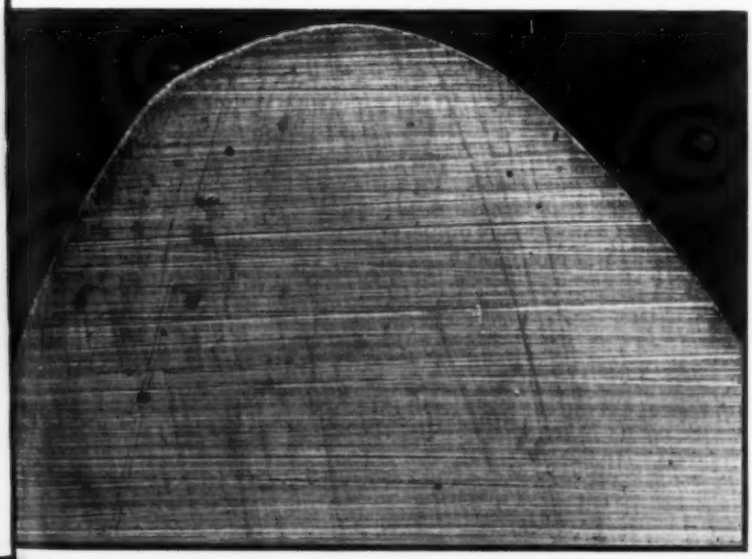


Figure 2 — The correct amount of chromium which should be applied to a round nosed cutting tool is illustrated in this figure.

GAGES

The application of chromium plate to gages is made to rectify mis-machined gages, to reclaim worn gages, and to obtain increased life and efficiency of either new or old gages. Since chromium plating can be stripped from the steel without removing the base metal, it can be replaced an indefinite number of times. In the successful application of chromium plating to thread gages, using the high speed high temperature process, the preferred procedure developed was to apply the chromium plate in amount in excess of the wear tolerance and resurface by finish grinding. Unusual life increases have been reported in certain cases where records were available, amounting to more than a 10-fold increase in useful life. These figures should not however, be taken as the expected improvement in all cases, but that there is a definite and substantial life increase is well established. The chromium plating of plug gages, etc., is old and well established. The use of chromium plate on thread gages is less widespread.

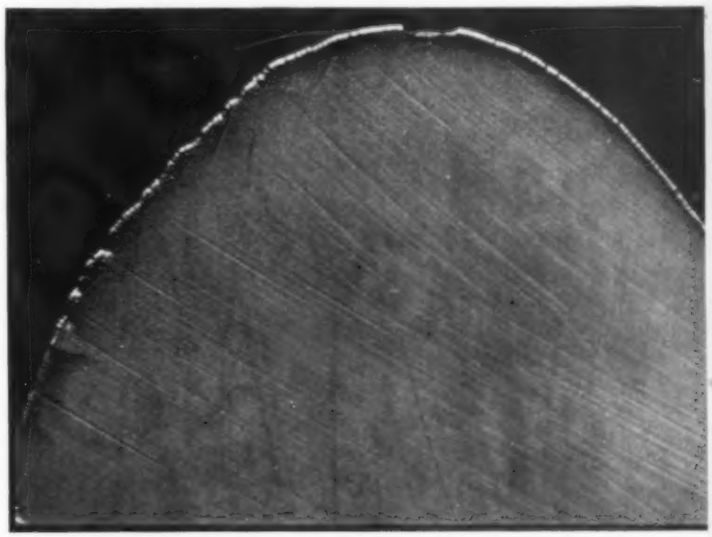


Figure 3 — When an excess thickness of chromium is applied to a round nosed cutting tool, beading such as is illustrated on the edge of the tool occurs.

MIS-MACHINED PARTS

Under the general heading of mis-machined parts might also be included machine elements that are off dimension due to warpage in heat treatment, and maintenance parts that are required outsize. The chromium plating of mis-machined parts may be considered a production matter, rather than one of maintenance, but is of interest nevertheless. Reclamation of such parts has been accomplished by the application of chromium even in thicknesses of 75 and 100 thousandths of an inch. Parts that have been reclaimed by chromium plating after either mis-machining or warpage include the bores of screw pinions, roll journals, well shafts, pallet shafts for conveyors, roll center inserts, etc. Cylinder sleeves for air hammers can be stocked in a single size and chromium plated to fit the particular replacement requirement in maintenance of that tool.

WEARING PARTS

The greatest benefit of chromium plating in maintenance lies in the application to wearing parts. Here the benefits accrue from an extension of life, from a reduction of the attention necessary to maintain the machine in continuous smooth operations, and from improved machine performance.

A very satisfactory application of chromium plate was made to the ram of a 500-ton forging press at the Steelton plant of the Bethlehem Steel Company. Figure 4 shows this press and its chromium plated ram after 1000 days of service. Already the life of this ram is over twice that of the best previous unplated ram used in the history of the press. The increase in life of the ram is not the only advantage obtained from chromium plating. A very important saving is in leather packings. On a new cast iron ram a leather backing would last about one week, but before the ram was removed from service the packing had to be renewed every day. On the chromium plated ram the leathers last five to six weeks, and after more than two years of service they are still lasting that length of time.

A multiple radial drill press was disassembled and all worn shafts and gear bores were chromium plated and finished to size. This was done because spare parts were not available during the war. Since its reinstallation into service after reconditioning by chromium plating, the press has given trouble free operation with unexpectedly low maintenance requirements.

Air hammer pistons normally requiring replacement in about six weeks were found after chromium plating to last as long as fifteen months. In addition the chromium plating of the piston eliminated sticking that occasionally occurred after storage of the tool. It is interesting to note that the chromium plating of the piston reduces to a very marked degree the wear on the sleeve. By adjusting the outside diameter of the sleeve through chromium plating to fit into its socket in the hammer, it has become unnecessary to stock non-standard sleeves; likewise only standard pistons need be stocked, since their diameter can be readily adjusted through chromium plating to conform to the refinished bore of a worn sleeve. These observations on air hammers verify the results previously obtained by others. The spindle of an exceedingly high speed grinder was found to operate cooler, eliminating the necessity for shut-down requirements due to heating. The chromium plated spindle is still in operation and has exceeded the previous normal life of an unplated arbor.

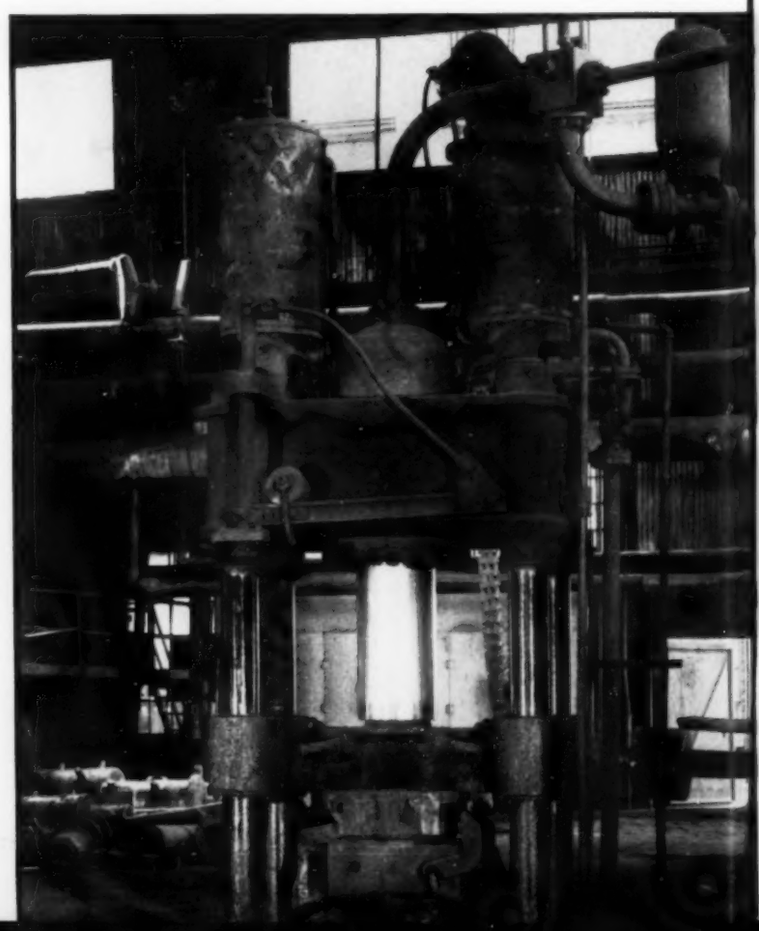
The chromium plating of pump plungers has resulted in a decided improvement in maintenance attention required for the adjustment of the packing glands. In one case where a booster pump required tightening once every shift and packing replacement once a week, after chromium plating the plungers have been running for five months with the requirement of but one packing adjustment per month and no packing replacements thus far. This observation has been duplicated in several instances.

Certain large hydraulic valves, some quite complicated, were chromium plated internally with the result that wire drawing was eliminated. Another result of benefit was found in that increased power was delivered to the operating equipment from the valve due to the lowered friction within the hydraulic valve. The elimination of wire drawing by chromium plating of steam reducing valve seats has also been observed.

Shafts which have become scored on their bearing surfaces have been reclaimed by grinding out the scored areas and plating back to size with chromium. Scoring that resulted from the disassembly of pressed fit components was likewise rectified by chromium plating to size after grinding out the scored areas. The chromium plated part was then reinstalled by press fitting. The life of a chromium plated machine part may be extended indefinitely by electrochemically stripping the chromium when it is finally worn beyond tolerance limits, and re-chromium plating. Since the stripping can be accomplished without harm to the original steel surface, it can be replated without further mechanical preparations. It is inherently wasteful to specify a thickness of chromium on a given part that is substantially greater than the allowable wear tolerance. The specification of chromium on members that are subject to failure by fatigue, although often feasible, is a matter for thorough engineering evaluation.

The foregoing description of selected applications that have been made of chromium plating in connection with maintenance operations may serve to illustrate the possibilities that lie in this useful tool. From the very nature of maintenance operations, chromium plating is most useful when facilities for its application are locally available. With the newer process for chromium plating

Figure 4 — The ram of this 500-ton forging press was chromium plated. The photograph shows the ram after 1000 days of service.



at high speed with the consequent condensation of time and equipment, it is now feasible to operate in a maintenance department just as with any other useful machine tool.

CHROMIUM PLATING PRACTICE

More than ten years ago the writer applied a chromium plate 0.015 in. thick to a worn machine element in order to reclaim it. Using the best practice available at the time, 45 hours were required to accomplish the plating. During this plating operation, the conditions had to be checked every few hours, and the operation was continuous. It was not difficult from this experience to reach the firm conclusion that for the production application of thick electrodeposits of chromium it would be necessary to have available much more rapid means of applying chromium plating.

In a given process of electrodeposition, sound and useful coatings are obtained between definite limits of current density. If, in the endeavor to increase the speed of plating the current density is raised beyond the upper limit, a "burnt" coating is produced that has little if any practical use. In order to develop a high speed chromium plating process careful studies were made within the range of the prior art, which was rather completely available, without successful results. Much further work resulted in the establishment of hitherto unrecognized principles and in the development of a successful process that is described in considerable detail in the patent specification.

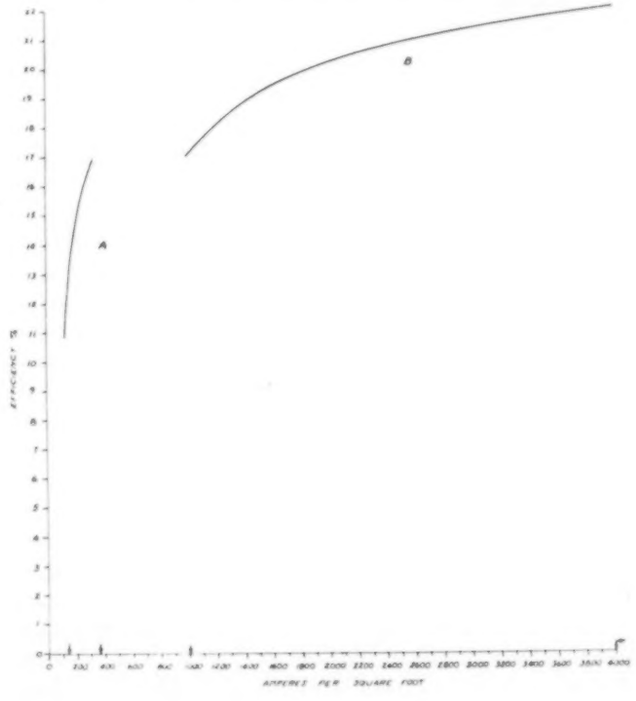
In very brief terms the process achieves the use of high current densities using a chromic acid plating bath containing a high concentration of sulphate radical in conjunction with high temperature. In addition to fulfilling the engineering requirement of high rate of chromium plating, the process development also furnished a chromium plate of markedly improved quality for mechanical use, especially in its resistance to impact, and in addition an improved throwing power.

Figure 5 shows the relation between the efficiency and the current density of two different processes. The curve marked "A" represents the present practice of most of the chromium plating for engineering use today. The curve marked "B" pertains to the new high current density high temperature process. Curve "A" shows the variation of efficiency with current density for a plating solution containing 250 grams per liter of chromic acid and 2.5 grams per liter of sulfuric acid, operated at a temperature of 55 C, according to the recommendations and the practices that are generally accepted. Curve "B", representing the high speed process, represents the efficiency current density characteristic of one of several acceptable baths, which contains 275 grams per liter of chromic acid and 5 grams per liter of sulfuric acid, operating at a temperature of 70 C. The difference between these two particular plating solutions is a negligible change in chromic acid concentration, a doubling of the sulphate content and a substantial increase in temperature. The greatest difference, of course, is in the current densities used. It is of interest to note that high current density solutions are still operating after more than eight years of continuous use.

If it is recalled that not so long ago most metal electroplating was in general accomplished at current densities of the order of 10 to 20 amperes per square foot, and that the use of the order of 250 amperes per square foot for chromium plating had created definite problems in existing operating establishments, it is not difficult to appreciate that the proposal to use current densities from 1000 to 3000 or more amperes per square foot was considered impractical by most people. As it turned out it was not at all impractical to use such high current densities. The development of the principle of fixture design for high speed plating successfully removed the difficulties thought to be inherent in such rapid operations. Adequate current carrying capacity for the components of the fixture, and reasonably close spacing between the insoluble anode and the work are the principal requirements for the fixture. An individual fixture costs more to construct for the high speed process, but since substantially fewer are required, the unit cost is less. Due to favorable polarization relationships at both the anode and cathode, the operating voltage at high current density is nominal. The principal controlling factor in operating voltage is the spacing between anode and cathode.

The high speed process, the efficiency characteristic of which is represented by curve "B", Figure 5, results in improved throwing power. The amount of metal deposited at a given point is proportional to the product of the current density and efficiency. The primary metal distribution therefore is proportional to the ratio of this product related to the near and far points of the work

Figure 5 — These curves show how efficiency varies with the current density in chromium plating. Curve "A" gives the figures for the low current density process according to Fink, and curve "B" gives the efficiency for the high current density process according to Wick.



being plated. By virtue of the lowering of the ratio of the efficiencies at the points of high and low current density, the throwing power is improved in that degree. The complete and rigorous analysis of this question of throwing power would involve the relative polarizations which, however, do not affect the result to an appreciable extent. It is because of this improved throwing power that it was found possible to plate thread gages by the use of the high current density process.

Electroplating generators having a voltage of 8 or 9 volts are preferred to those rated at 6 volts for the high speed plating. By virtue of the higher operating efficiency, proportionately more chromium is electrodeposited with a given amperage. One of the most significant and practical effects resulting from the high speed chromium plating process is the reduction in the tank capacity required for a given volume of work. Because of the extremely broad range of current densities resulting in sound chromium plate that are available, it is a matter of engineering choice to obtain most economic operations as to the current densities selected for a given job. For the most part, from 1000 to 3000 amperes per square foot is used. Lower and higher values, up to even 10,000 amperes per square foot, can be used if desired. Hence, it is usual to plate speeds of 3 to 8 or more thousandths inch per hour, and in contrast to about one thousandth, it is evident that the number of tanks required to deliver a given volume of work is reduced very materially. There is a corresponding reduction in floor space required. This simplification of equipment has consequences that are obvious in regard to the feasibility of installation and utilization of chromium plating facilities for engineering use.

From the operating standpoint a useful result is obtained through high speed plating by virtue of the ability to apply desired heavy coatings of chromium plate within a single work shift. Where coatings of a thickness of ten thousandths inch or more are desired, the plating normally requires more than one shift to accomplish with the older processes and less than that with the high speed process. Should existing operating requirements render it undesirable to incur multiple work shift operation, then the ability to complete a given chromium plating operation within a single shift becomes desirable. For large volume production, of course, multiple shift operation is more economic.

Earlier reference was made to the recommended practice specification of the ASTM on chromium plating. This specification covers with substantial completeness the necessary details of the preparation of steel for plating. General experience in these operations has indicated the importance of adequate electrolytic alkaline cleaning, for which a light duty cleaner that is replaced at reasonable intervals is recommended. Scrupulous attention to the cleaning and etching steps, which are very simple, is sufficient to insure high quality in the product. ASTM specification warns against excessive hardening of the steel base prior to plating, recommending that a hardness of about 58 Rockwell C not being exceeded. Very extensive hardness of the base metal may result in cracking due to the initial stresses in the chromium as plated. It is sometimes desirable to relieve these stresses by heat treatment in oil, for example, at about 400 F, for one-half hour at temperature. In reality, different steels having different processing histories, vary in their maximum applicable hardness from 48 to 62 Rockwell C. It is sufficient to recognize these factors in order to establish the operational specifications for the treatment of different products.

The final finishing of chromium plate is usually accomplished by grinding. The manufacturers of grinding wheels have done an excellent job in the development of wheel grades and specifications for providing different finishes required on chromium plate. Best results are obtained by chromium plating on a ground steel surface that is no coarser than a "good commercial smooth finish," (r.m.s. 63). When the plating is applied with minimum excess thickness, determined by experience, this practice results in a minimum of grinding of the chromium. In many applications the chromium may be plated to finished size, as is the case with certain brake drum, arresting gear hooks, hydraulic buffer pistons operating with leather packing glands, etc.

Recent reports by independent workers in the field have indicated that the physical properties of chromium electrodeposited at high temperatures is superior for mechanical use than that from low temperature baths. No doubt this matter will be the subject of substantial further investigation. It is evident from widespread experience that chromium plated from the low temperature baths is adequate for very many uses, and that the high current density chromium process permits the extension of the use of chromium plate to applications where high stress concentrations may be encountered. In the high current density high temperature chromium plating process, the chromium has been found to have a hardness of about 825 Vickers Brinnell, which is of the order of hardness of a sapphire. It is possible to plate chromium very much harder than this, but at the sacrifice of a quality that might be termed "toughness." Since in this range of hardness the load-penetration curve is so very steep, it is felt that differ-

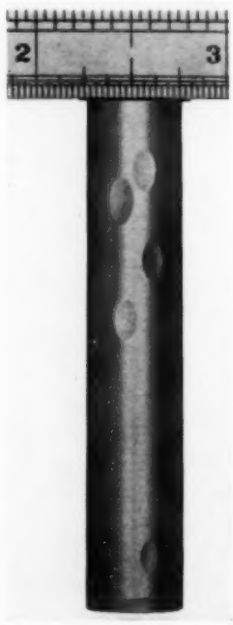


Figure 6 — The chromium coating is malleable enough to deform with the steel without cracking.

ences in hardness number in this extreme range is of lesser significance than proportionate differences in the lower range of hardness. Certainly, observations on the wearing characteristics of the chromium produced at high temperature supports this view.

In the attempt to demonstrate the quality of malleability, resort was had to a test utilizing a ½ in. diameter rod specimen on which the chromium plate was 0.005 in. thick. This specimen was subjected to blows of sufficient intensity from the rounded end of a ball pein hammer to cause permanent deformation of the base steel. The result is shown in Figure 6. It is noted that the chromium has deformed with the steel without cracking or flaking. This specimen was prepared after observing the ability of certain machine elements to withstand severe impact, and may serve to describe the quality which has been termed "malleability." In the series of specimens of this sort that have been prepared, a crack may appear in one of 15 or 20 such indentions.

Chromium plating has been called "a putting-on tool." It is literally that, and since it imparts to the machine elements to which it is applied, a longer life and a reduced requirement for attention in many cases, it can be of material aid in maintenance. Not infrequently parts to which chromium is first applied for maintenance reasons are thereafter specified as chromium plated on new installations. This is a tribute to the merit of the original application and, to a degree, is indicative of the probable future developments utilizing this useful practice of chromium plating for engineering use.

DISCUSSION

PRESENTED BY

E. T. CANDEE, Director Research and Development, Lea Manufacturing Company, Waterbury, Connecticut

L. F. COFFIN, Superintendent, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland

R. M. WICK, Research Engineer, Bethlehem Steel Company, Bethlehem, Pennsylvania

A. D. HOWRY, Assistant Superintendent Maintenance, Electrical Department, Alan Wood Steel Company, Conshohocken, Pennsylvania

M. B. ANTRIM, Electrical Engineer, Lukens Steel Company, Coatesville, Pennsylvania

FRANK A. BAKER, JR., Assistant to Chief Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

C. S. CASSELS, Plant Engineer, Henry Disston and Sons, Inc., Tacony, Pennsylvania

A. E. CICHELLI, Lubrication Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

J. C. HARRIS, General Manager, Drever Company, Philadelphia, Pennsylvania

E. T. Candee: Chromium plating is not new. It is fifteen years old, possibly, but I am afraid in many cases chromium plating has not had as good a name as it should have because out of ten pieces you get plated, three or four or more, will fail, usually by the breaking or the peeling off of chromium plating. That has been caused chiefly by ignorance. Chromium plating caused one of the greatest upheavals that ever occurred in the plating industry, and, of course, when you have an upheaval, everybody makes mistakes through ignorance and poor work results.

I am rather familiar with the work done by Dr. Wick. I have seen some of the results and today it looks to me as if chromium plating can be considered a production tool the same as any other machine tool in your maintenance shop. I am not so sure but what this will extend plating beyond a maintenance tool, to a strictly production tool. Very likely cheaper chromium plated steels can be used and thus eliminate considerable hardening, the accompanying warpage and all the other difficulties that go along with hardening.

This process is not new but it has not been in common use, because Dr. Wick, being rather a meticulous investigator, has watched it under his supervision for a good many years. I feel quite confident, if anybody were to put this chromium plating process in their maintenance shop today, they would find it no more difficult to operate than a milling machine or lathe or any other tool. It would operate quite well, shall I say, over in the corner, if it is operated intelligently.

L. F. Coffin: In a large steel plant a chromium plating plant is probably a necessity for the best grade of maintenance. One interesting application of chromium plating is its use on oil seal rings in hot strip mill oil lubricated back-up roll bearings. These rings are 32 in. outside diameter by ¾ in. square cross section, made of bronze, machined and ground accurately on a rotating magnetic chuck table grinder. They are then chromium plated and used without further grinding. The increase in life has been quite considerable. I would like to ask Dr. Wick whether on much of the work you do on thread gages, for instance, and other similar work, you make a practice of endeavoring to chromium plate without further grinding?

R. M. Wick: In general it is not the practice to chromium plate without further grinding in order to obtain the maximum dimensional accuracy and finish required in the specification. However, there are a number of applications in which it can be done. As far as plating to size is concerned, there is in chromium plating the opportunity of very close control and one can plate to tolerances of one or two 100/1000'ths of an inch successfully.

A. D. Howry: I find that Dr. Wick's discussion is of vital interest to those of us who use Schuylkill River water in our hydraulic systems, the abrasive action of the water incurring undue wear and replacement of all moving parts. In addition, the proper application of chrome hits a responsive chord, as recently we had an instance of chrome flaking that was rather expensive; we have a number of mercury arc rectifiers, the excitation of which consists of chrome plated solenoid plung-

ers, operating in a tube sealed in each tank. Due to flaking of the chrome on the collars of one plunger, the plunger jammed, involving a complete disassembly of the tank, and replacement of the plunger. The chrome flake was of microscopic size, and all out of proportion to the replacement cost of between two and three hundred dollars.

M. B. Antrim: I would like to ask Dr. Wick if he would tell us whether gearing may be practically plated with chromium, and also shafting, such as the wearing parts in babbitt or bronze bearings?

Frank A. Baker, Jr.: I would like to ask Dr. Wick whether anodizing of chrome plated surfaces is still used and if so whether it improves the quality of the lubricating film for wearing parts?

C. S. Cassels: We may have an application for chrome plating in one of our grinding processes. We use rather small diameter steel rolls to feed sheet steel to a grinding wheel. The rolls are exposed to the coolant water on the wheel and consequently carry a certain amount of abrasive around with them as they are feeding the steel sheets. Naturally the wear is very high. Would such a point be a possible application for chrome plating in order to increase the life of the rolls? Will chrome plate stand up under the crushing action of the small pieces of abrasive?

A. E. Cichelli: I should like to ask Dr. Wick two questions. He mentioned chrome plating pistons for air hammers. Is there any objection to chrome plating the cylinder wall as well as the piston, or must one of the surfaces be steel?

The second question concerns a job done some time back when Bethlehem chrome plated a gas engine piston rod. I wonder if Dr. Wick is in position to tell us something about that tonight?

J. C. Harris: I would like to ask the maximum temperatures on oxidizing conditions that chrome plating is good for?

R. M. Wick: Mr. Howry's description of the failure of adhesion of the chromium plate on a solenoid plunger is an example of improper preparatory treatment of the steel before chromium plating. It does happen, however needlessly. Obtaining adhesion through correct steel surface treatment is essential to satisfactory chromium plating. It can be done by the use of established practices which were reported during the war, in connection with the work in ASTM. Since chromium plating is inherently resistant to corrosion and is finding numerous successful applications to hydraulic systems, it is evident that chromium plating would be useful in connection with the Schuylkill River water problem.

In connection with the question of Mr. Antrim on the application of chromium to gear teeth, the success of this application is probably dependent on the load. There should be an application for light loadings, but for intermediate and heavy loadings, a service test should be made to establish that chromium plating is beneficial in the particular case. Incidentally, we have not undertaken to chromium plate gear teeth. However, it should be useful to test this application. The success of the application will be determined largely by the intensity of the bearing stresses, and the grinding characteristics between working surfaces of the interlocking teeth.

Mr. Baker inquires about anodizing the chromium surface to obtain improved lubrication. Anodizing is one of several ways to obtain porous chromium. This type of chromium has served excellently for its special purpose. It has been widely applied on the internal surfaces of aircraft engine cylinders, and before that on diesel engine cylinders. The oil-retentive property of porous chromium, combined with the wear-resistance and low coefficient of friction characteristic of all chromium plate, has made an excellent record in special and difficult applications. There was a very sharp reduction in the use of porous chromium following the war, as might be expected. The application of porous chromium is a rather difficult technology, in that a substantially high degree of precise control is necessary to accomplish it successfully. Porous chromium will be with us for a long time because of its particular and special properties. In nearly all cases a properly applied solid chromium plate is to be recommended for a given job.

Mr. Cassells remarked on small diameter rolls to feed sheet steel to a grinding wheel, and said the roll was being exposed to liquids containing abrasives. Chromium might be applicable there, depending entirely on the nature of the abrasive. There have been cases of a similar nature where chromium worked out very well. A service test is in order for the particular application.

Mr. Cichelli has asked whether there is any objection to chromium plating the cylinder wall as well as the piston of air hammers. Chromium is not usually used on opposing wearing members of a mechanical system. Except in cases where corrosion is a factor, it is not necessary to apply chromium plate on both members. Many years ago it was observed that when chromium was applied to one of two wearing members, the wear on the opposing member, not chromium plated, was markedly decreased. For many air hammers having a small bore, it is more practical and equally effective to chromium plate the outer surface of the piston than it is to plate the inside of the cylinder.

Gas engine piston rods were not mentioned in the paper, although their treatment is undoubtedly a maintenance matter. Gas engine piston rods have worked out very well. The observation on the first trial of this application is still in progress, and it was installed in December, 1942. From that you can judge that the application is an excellent one.

Mr. Harris asked about the maximum temperature under oxidizing conditions, in which you could use chromium. Chromium will blacken if heated under oxidizing conditions. However, by heating chromium at 1700 F, one obtains soft chromium, similar to that obtained through the melting processes, and one may obtain likewise an alloying with steel. Chromium could be used to temperatures of 1000 or 1200 F. I have had no experience using it at higher temperatures than that. Attention is called to the possible use of nickel in some high temperature applications; some old tests on a nickel plated bolt in a boiler showed that it lasted several times longer than a plain steel bolt.

PRACTICAL METALLURGY

For the Steel Mill Engineer

. . . . proper selection of steel for steel plant equipment will reduce operation and maintenance costs . . .

By W. B. McFERRIN, Metallurgical Engineer
Electro Metallurgical Company
New York, New York

▲ THE average engineer of today thinks and speaks of metallurgy as being relatively new. This, however, is not quite correct. It was recorded in some of the early writings of the Hebrew race around 4000 B.C. that Tubalcain was a teacher of the arts of refining and working of the metals of iron, brass, gold and silver. Therefore, metallurgy as an art may be likened to a wise old man who impresses everyone with his wisdom. Metallurgy as a science, however, is a mere babe.

Man has accumulated considerable knowledge about the effects of the various chemical and physical reactions entering into the metallurgical processes, but he has paid little attention until recently to the causes, the underlying fundamentals which are the controlling factors in understanding the nature of all metallic materials.

The metallurgist of today who tries to keep abreast of the important developments in his field finds life full of trials and tribulations. The steel mill engineers encounter the same problems as the metallurgist in attempting to keep abreast of the new developments in their field. It becomes a more than difficult task if he attempts to keep up to date in both fields. It would be far better if the specification of all metallic materials used in construction and for maintenance was left to a joint committee which was composed of representatives from the designing, maintenance, and metallurgical engineering departments. The only exception, of course, being the materials used in the construction of mill units, sub-assemblies, machines, etc., supplied by contractors.

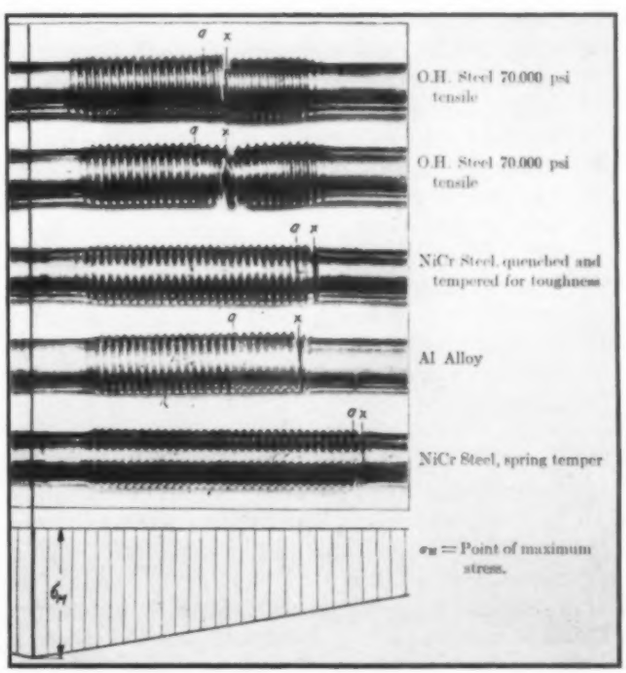
In most large industries, if closely inspected, one will find examples of the improper application of materials. I think if steel mill maintenance record files were closely scrutinized, you would find numerous parts requiring frequent repair or replacement on which consultation with your metallurgical department would result in tremendous economy in both time and money.

During the past few years, as a result of World War II, we have seen the leading engineers and metallurgists of this country become more conservation conscious. It is estimated that the value of the annual loss of metal by corrosion in this country is between one and two billion dollars. It also has been estimated that forty per cent of the entire iron and steel production since 1890 has been lost through corrosion.

The major concern of the steel mill engineer is that of obtaining smooth and efficient operation and the prevention of costly repair and maintenance operations. Therefore, it might be well at this time to mention several methods of processing which have been developed in the last 5 to 20 years and are being applied to parts of machines and equipment which are subject to fatigue, wear, and stress corrosion failures.

1. *Shot peening*—This consists in cold working the skin surface of the parts by shot blasting with small, round iron or steel shot. This relieves tensile stresses in the skin surface by placing this surface

Figure 1 — Benefits of cold working threads by rolling are shown. The worked threads extend only from the left to point "a" in each case. Those to the right of "a" were unworked. The rotating specimens were cantilever loaded through a bearing at the right so that the stress increased as indicated at the bottom of the figure from right to left. Failures occurred in the unworked threads, although the stress there was lower than in the worked threads.



Presented before AISE Detroit District Section Meeting, March 9, 1948

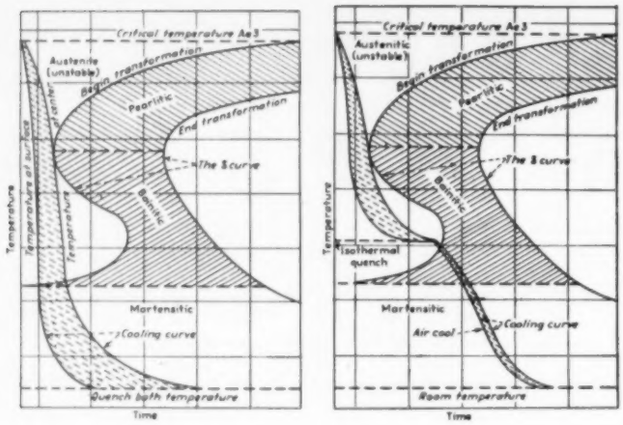


Figure 2 — On the extreme left is a time-temperature transformation curve for steel. The dotted cross-hatched area at the extreme left represents a cooling curve on a water quenched specimen where the specimen is quenched from above the critical temperature in a water bath at room temperature. You will notice a wide temperature gradient within the specimen which tends to promote drastic internal stress, especially when the part passes through the martensitic transformation range and martensite is formed. The figure at the right of the slide illustrates a cooling curve when following martempering process in relation to TTT curve. Note that the part is quenched into bath which is above the MS point (450 F) and held at that temperature for a period of time to permit equalization of the temperature within the specimen. Then it is rapidly air cooled or quenched to room temperature. This reduces greatly the stress set up within the part when it transforms from austenite to martensite, as the entire part of the tool tends to transform at the same time.

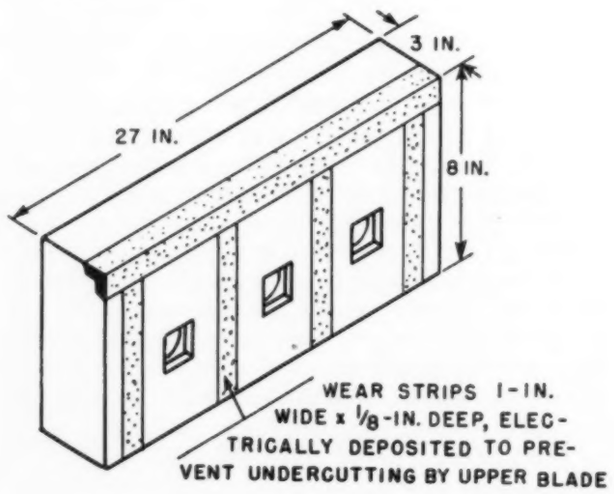
in compression. However, this remedy must be applied with caution, for if the cold work goes so far as to produce tiny cracks in the cold worked surface layer, the cure is worse than the disease, but up to that point the effect is somewhat comparable to that of putting on a strong (hard) very thin layer.

2. *Cold working the outer surface by rolling*—Cold working of shafts and other parts by rolling the surface has received considerable attention. Cold working reduces the surface imperfections and reduces the possibilities of stress raisers. The benefits of this practice have been demonstrated by several investigators. The moderate working of the surface of the shaft is accomplished by placing it between three hardened rollers spaced at 120 degrees or four at 90 degrees held in a framework to which the desired pressure can be applied. Similar practice has been applied to railway axle shafts, keyways, threaded parts, etc. Figure 1 [1]* illustrates the benefit of cold working threads by rolling. The worked threads extend only from the left to the point "a" in each case. Those to the right of "a" were unworked. The rotating specimens were cantilever loaded through a bearing at the right, so that the stress increased, as indicated at the bottom of the figure, from right to left. Failure occurred in the unworked threads, although the stress there was lower than in the worked ones.

3. *New or improved methods of heat treatment*—
   A. Controlled atmosphere heat treating furnaces which permit performance of complete or partial machining operation before final heat treatment.
   B. Refrigeration — low temperature transformation, that is, subzero transformation of residual austenite into martensite. This form of heat treatment is used primarily in improving hardness, stability of structure, and physical properties of certain tool steels and alloy steels.
   C. Isothermal heat treating process, martempering, austempering and "cyclic annealing." Isothermal quenching, martempering, austempering, and "cyclic annealing" are names applied to controlled interrupted quenching in hot baths. Figure 2 [2] gives a graphic illustration of some of these processes. Martempering can be used to advantage to obtain maximum hardness in small, intricate parts after being completely machined without danger of distortion, quench cracking or scaling. Austempering process can be used to attain hardness of C-45 to C-55, along with excellent toughness and ductility in small, completely machined parts such as chisels, springs, etc. By the "cyclic annealing" process, in a good many cases, the long furnace cooled annealing cycle normally requiring 18 to 30 hours may be completed in 4 to 7 hours.
   D. Flame hardening or induction hardening—flame hardened and induction hardened surfaces are being used increasingly for wear resistance.

4 *Flame strengthening*, which in reality is nothing more than flame hardening. This method has been used with success in eliminating failures in axles which were press fitted into hubs. Failure normally occurs in axles, crane hooks, and shafted gears at the point of localized stress concentration.

Figure 3 — Application of hard surfacing alloy to this blooming mill shear blade gave an estimated life of 65,000 turns.



*Figures in parenthesis refer to bibliography at end of article.

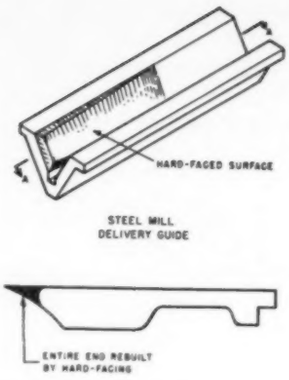


Figure 4 — Increased life was also obtained on this hard-faced entry twist guide.

Cold working and flame strengthening are only two of many possibilities for minimizing this condition.

5. *Carburizing, nitriding and hard surfacing*—These methods have been used to strengthen the surface of many parts, although the primary purpose is usually for the prevention of wear. The behavior of the notched carburized steel with a notch made prior to carburizing in rotating-beam fatigue test has been studied by Boegehold [3] and others. Moore and Alleman obtained the following results on steels with a carburized case of 0.02 in. to 0.03 in. deep, oil-quenched from the pot and heat treated for case and core given in Table 1 [4]. You will notice that the notched untreated steel varies in endurance limit from 28,000 to 48,000 lb psi, depending upon type of steel, while identical specimens which were carburized, with notch made prior to carburizing and quenched directly from pot then heat treated for core and case, gave an endurance limit of from 70,000 to 100,000 psi which was over twice that obtained on the untreated notched specimens. When quenching irregularly shaped carburized parts the possibility of forming quenching cracks should be guarded against. In very highly stressed parts such as airplane motor parts, nitriding is often used in preference to carburizing. Since nitriding does not involve quenching, the hazard of cracks is less when using this process.

TABLE I

Steel, SAE	Untreated	Carburized
1020	28,000	70,000
2320	48,000	100,000
3120	38,000	90,000

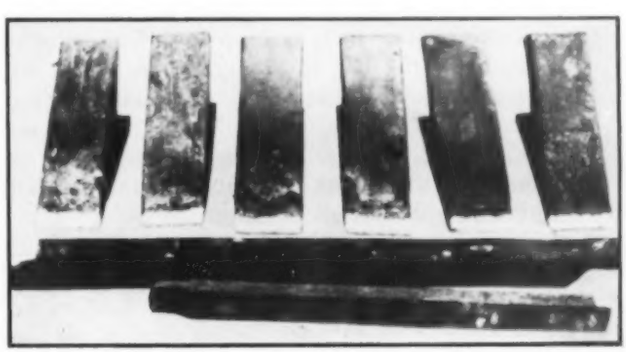
6. *Hard surfacing alloys*—The application of hard surface alloys by welding is one of the processes used by the engineer to delay the normal deterioration of equipment and obtain increased service life. The simplest classification of these alloys is according to base metal used in the alloy rod instead of the alloying elements. In following this system of classification there would be only four general groups of hard surfacing materials:

Group A—Iron base alloys.
Group B—Nickel base alloys.
Group C—Cobalt base alloys.
Group D—Tungsten base alloys.

The base metals in any one of the above groups will be alloyed with two or more of the following: carbon, boron, chromium, tungsten, nickel, cobalt, manganese, silicon, vanadium, molybdenum, zirconium, titanium, tantalum, and columbium. These alloying elements are added to improve the inherent properties of the base metal as well as impart additional properties. The problem of selecting the right rod for a given application can best be solved by those specializing in the manufacture of these types of alloy rods. All four groups of hard surfacing alloys find some use in the steel mills. Figure 3 shows typical application of Group B alloy to blooming mill shear blades which resulted in an estimated shear life of 65,000 tons of 8 x 8 in. blooms before resurfacing of blades was necessary. Figure 4 shows typical application of Group B hard surfacing alloy to delivery guide and entry twist guide. These hard surfaced guides last approximately eight times as long as plain carbon steel guides or four times as long as high alloy steel guides. The dipper teeth and latch bars hard surfaced with Group C rod shown in Figure 5 resulted in surface life of over three times that normally expected. There are no doubt numerous other applications for which this process could be used to advantage.

7. *New welding techniques*—Among the newer welding processes now being used by the steel industry is the submerged melt process. In this process a supply of melt is laid down along the seam to be welded in sufficient depth to completely cover the end of the welding rod at all times during the welding operation. The entire welding action takes place beneath this granulated material without sparks, spatter or flash. Since unusual depths of fusion can be obtained and extremely heavy deposits of weld metal made automatically, the steel industry has found this process ideal for many salvage operations. These include such items as the build up of crane wheels, gears, table and finishing rolls. The normal procedure in building up table rolls is to leave the normal weld deposit intact without subsequent machining since this slightly roughened surface provides better trac-

Figure 5 — Hard facing the dipper teeth increased life over three times.



tion for the steel. On the finishing rolls the surfaces may be rebuilt by welding, machined and then flame hardened to provide an extremely hard and long wearing surface. Figure 6 illustrates a typical example of the application of this process in the steel industry.

8. *Metal spraying*—This has found some application in rebuilding shafts, gears and bearing surfaces which are subjected to wear.
9. *Metal plating* (chromium, nickel, cadmium and zinc) to improve corrosion and/or wear resistance are being rather widely used. This process, however, should be applied with caution because it has been found that plated coatings have different effects upon different metals, depending upon the nature of the coating. This is especially true if the part is subjected to alternating stress in the vicinity of its endurance limit. A glance at the chart in Figure 7 [5] will serve to thoroughly emphasize the importance of taking all possible precautions in the elimination of corrosion and notch effects in highly stressed parts. The upper area of the diagram shows the expected endurance limit for unnotched, polished specimens. The upper line represents the possibilities of specimens for properly selected homogeneous stress free steels in which every type of notch effect has been successfully avoided in designing, machining and servicing of the parts. However, if this care is not exercised in the choice of the steel and processing, the endurance limit for the part is likely to approximate that for notched specimens. When notches are present, the behavior differs both with the notch and with the steel, that is, no ratio holds true. If notches must be present, as in bolt threads or when oil holes are required, there is little if anything to be gained by raising the tensile strength above 125,000 psi for the increased endurance limit on smooth bars for the higher strength steels is neutralized by their increased notch sensitivity. Of course, high static strength may be required, but if design is based upon fatigue strength, the higher strength steel offers little advantage. Under corrosion fatigue conditions the lack of the advantage of the stronger corrodible steels is still more marked. This is to be readily seen upon studying the cross-hatched area at the bottom of the diagram. This is also illustrated in Figure 8 [6].

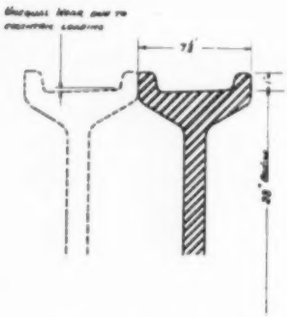


Figure 6 — Wheels may be built up by automatic welding thus increasing their life span.

Until approximately thirty years ago, there was little need for the engineer to know anything about metallurgy, as untreated carbon steels, hot rolled or cold drawn were used for at least 95 per cent of all steel structures and machines. The engineer was interested primarily in five properties, tensile strength, yield point, elongation, and reduction or area and hardness, and in having available an ample supply of cheap steel or metal which would meet specifications, machine easily and fabricate or cast readily.

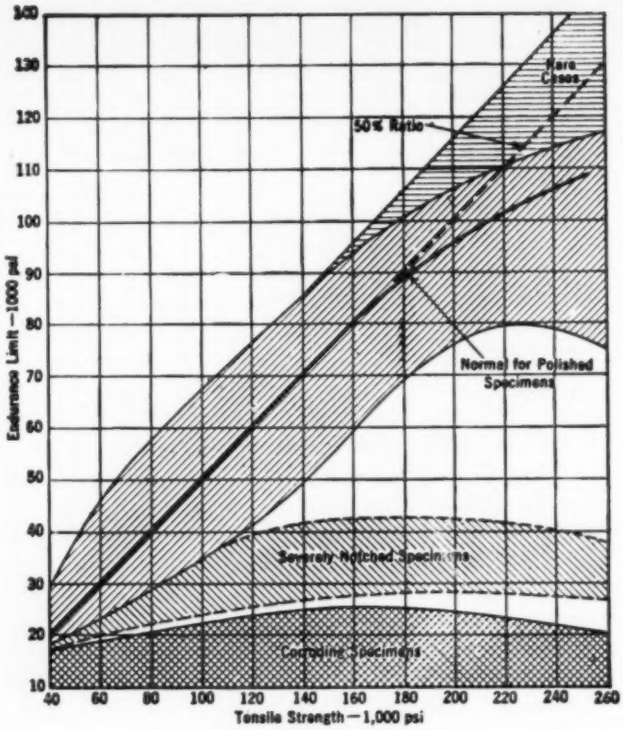
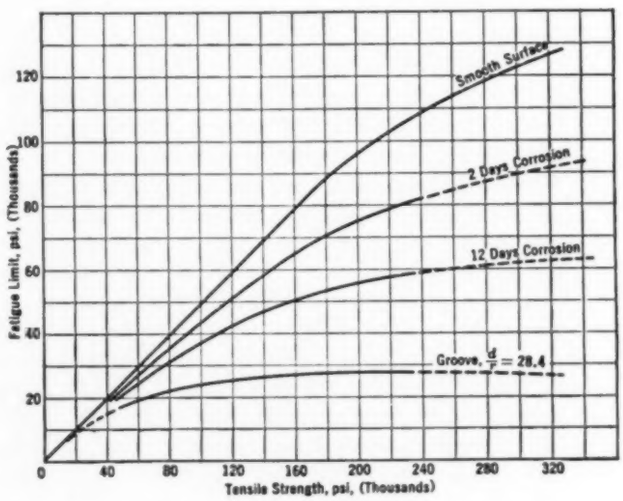


Figure 7 — The chart gives the general behavior in fatigue of polished, notched or corroded steel specimens compared with their tensile strength.

The engineers of today are interested in a variety of additional properties, some of which are as follows: heat, corrosion and abrasion resistance, hardenability, weldability, formability, castability, electrical properties, dampening capacity, etc. Briefly, the ferrous and

Figure 8 — The curve shows the relation between tensile strength of steel and its endurance limit as the result of roughening the surface by corrosion in plain tap water or of grooving it mechanically prior to repeated stress.



high alloy materials and alloys used today in the construction and repair of various steel mill equipment may be roughly classified under the following headings: carbon steels, low alloy high strength structural steels, low alloy heat treating steels, tool steels, hard surfacing alloys, plain irons and alloy irons, heat and corrosion resistant alloys, sintered carbides, bearing metals, light alloys, and other non-ferrous alloys.

It is obvious that the present day emphasis on light weight in engineering design is directly related to the development of new types of steels, light non-ferrous alloys, hard surfacing materials, sintered carbides, and to new methods of treatment for these materials. This is further emphasized by the trend in industry toward specifying materials by physical properties (such as hardenability, low or high temperature properties, etc.) as well as chemical composition. The balance of this paper will discuss some of the engineering properties and suggested uses for these materials.

ALLOY STEELS

The manufacture and production of such steel mills as the modern high speed rolling mills and their auxiliary equipment producing sheet, structural shapes, bar stock, rails, etc., would have been impossible without alloy steels. The alloy steels for the purpose of convenience in discussing them will be divided into roughly three classes, which are as follows:

1. The low alloy high strength steels (usually known and designated by their respective trade names.)
2. The low alloy heat treating steels, better known as the S.A.E. or A.I.S.I. designated steels.
3. High alloy steels (heat, corrosion resistant or stainless types). The heat resistant and stainless steels have also been given S.A.E. and A.I.S.I. designations.

LOW ALLOY HIGH STRENGTH STEELS

This group of ten steels, with the exception of possibly two, are nameless insofar as official S.A.E. or A.I.S.I. classifications are concerned.

Table II [7] gives some data on brand names, compositions, minimum physical properties, and producers of these steels. These low alloy structural steels as a group are characterized by low carbon (which improves ductility and weldability, and prevents air hardening) and by the presence of between two and five of the following alloying elements, manganese, silicon, chromium, nickel, copper, molybdenum, zirconium and phosphorus in amounts in excess of those found in ordinary steels. It will also be noted that the composition is balanced so that hot rolled sections will have a minimum yield

TABLE II

Representative High Strength—Low Alloy Steels
Data given, except for noted exceptions, are for plate ½-in. thick in the hot-rolled condition

	Composition, %											Yield point min., Psi	Tensile strength, min., Psi	Min. elong.	Producer
Brand name	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Zr	Al				
Aldecor	0.12 max.	0.15-0.40	0.08-0.15	0.05 max.	0.35-0.75	0.35-0.60	...	...	0.16-0.28	...	...	50,000	70,000	a22 %	Republic Steel Corporation
Cor-Ten	0.12 max.	0.20-0.50	0.07-0.15	0.05 max.	0.25-0.75	0.25-0.55	0.65 max.	0.50-1.25	...	...	...	50,000	70,000	b-c	Carnegie-Illinois Steel Corporation Tennessee Coal, Iron and Railroad Company Geneva Steel Company American Steel and Wire Company Republic Steel Corporation
Double Strength	0.12 max.	0.50-1.00	0.04 max.	0.05 max.	...	0.50-1.00	0.50-1.10	...	0.10 min.	...	...	50,000	70,000	a22 %	Republic Steel Corporation
Dynalloy	0.20 max. 0.12 avg.	1.25 max. 0.75 avg.	0.100 max. 0.080 avg.	0.05 max. 0.035 avg.	0.30 max. 0.05 avg.	0.60 max. 0.40 avg.	1.00 max. 0.60 avg.	... ...	0.10 max. 0.08 avg.	... ...	... ...	50,000 ...	65,000/80,000 ...	b-d ...	Alan Wood Steel Company
Hi-Steel	0.12 max.	0.50-0.90	0.05-0.12	0.05 max.	0.15 max.	0.95-1.30	0.45-0.75	...	0.08-0.18	...	0.12-0.27	50,000	70,000	b-c	Inland Steel Company
Manganese-Nickel-Copper	0.25 max.	1.40 max.	0.045 max.	0.05 max.	0.25 max.	0.30-0.60	0.50-1.00	...	...	...	...	50,000	70,000	b-c	Carnegie-Illinois Steel Corporation
Mayari-R	0.12 max.	0.50-1.00	0.08-0.12	0.05 max.	0.10-0.50	0.50-0.70	0.25-0.75	0.40-1.00	...	...	...	50,000	70,000	b-c	Bethlehem Steel Company
N-A-X High Tensile	0.08-0.15	0.50-0.75	0.04 max.	0.05 max.	0.60-0.90	Resid	Resid	0.50-0.65	...	0.05-0.15	...	50,000	70,000	c	Great Lakes Steel Corporation
Otiscoloy	0.15 max.	0.90-1.40	0.08-0.13	0.04 max.	0.10 max.	0.30 min.	Resid	Resid	...	...	...	50,000	70,000	a-d25	Jones and Laughlin Steel Corporation
Yoloy	0.15 max.	0.60 max.	0.05-0.10	0.05 max.	...	0.75-1.25	1.50 2.00	...	...	...	...	50,000	70,000	a22	Youngstown Sheet and Tube Company

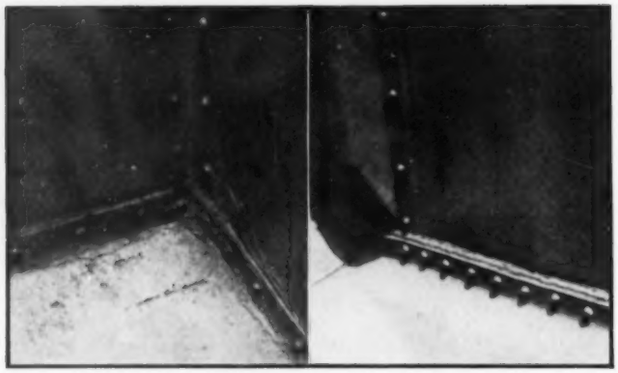


Figure 9 — The left hand view shows layers of rust and spalling which is typical of corrosion in plain carbon or copper steel hopper cars. On the right is shown the appearance of corrosion resistant high strength low alloy steel which forms a dense, adherent, relatively impervious rust. The car on the right has been in service ten years.

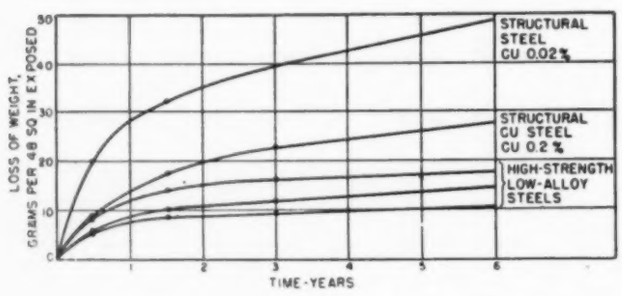
strength of 50,000 psi, a tensile of 65,000 to 90,000 psi and an elongation of 16 to 30 per cent in 8 inches, depending upon composition. The notch toughness of these steels is better than ordinary steels (plain carbon steels of same strength) whether based upon room temperature tests or in terms of the lowest temperature at which they preserve their toughness. Service tests have demonstrated that the abrasion resistance of these high-strength steels is considerably greater than that of ordinary steel. This superiority is especially pronounced where abrasive action is encountered along with corrosion, as in mine cars, freight cars, barges, ore cars, skips, etc. See Figure 9 [7].

The atmospheric corrosion resistance of these steels is reported to be 4 to 6 times that of ordinary steel, and at least twice that of the so-called copper steels (0.20 per cent minimum copper). See Figure 10 [7]. The rate of corrosion of any metal will depend upon at least two factors.

1. Factors associated mainly with the metal itself, such as composition, etc.
2. Factors external to the metal which vary with environment.

For example, steel in a dry atmosphere will corrode at an extremely slow rate, but in contaminated industrial atmospheres this rate is greatly increased. In ordinary steels and high strength low alloy steels the common effective methods of minimizing corrosion such as coating will not suffice unless care is exercised to keep surface conditions free from entrapped dirt and moisture. The designing engineer can help greatly in designing structures free from ledges or pockets which form traps for dirt and moisture. Compare Figure 9 with Figure 11 [8].

Figure 10 — Typical time-corrosion loss curves for representative steels of this group after exposure in an industrial atmosphere. Notice at the end of six year period that the loss due to corrosion of some of the high stress, low alloy steels is only 1/5 that of regular structural steel or ½ that of structural copper bearing steel.



LOW ALLOY HEAT TREATING STEELS, OR S.A.E. OR A.I.S.I. DESIGNATED STEELS

There are several hundred low alloy engineering steels, of which approximately 80 have been included in the S.A.E. and A.I.S.I. specifications. The S.A.E. steels have been divided into ten main classes—carbon steels, intermediate manganese, silicon manganese, nickel, nickel chrome, molybdenum (including chrome molybdenum and nickel molybdenum) chromium, chrome vanadium, tungsten and low alloy high strength steel. See Table III [9].

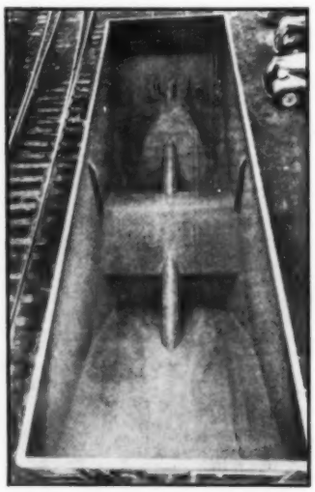


Figure 11 — The life of open freight cars is substantially lengthened by the use of smooth welded construction and high strength steel.

These classifications of steels may be further broken down to the following classes: carburizing grades, semi-through hardening grades, which are generally 0.30 per cent carbon or under and the through hardening grades which are, in most cases, over 0.30 per cent carbon.

These steels all have to be heat treated to develop the desired properties. They are used widely in the construction of all steel mill equipment. The engineering handbooks are filled with information pertaining to compositions, heat treatments and applications of these steels in industry and need no further discussion here. In summarizing the properties of this class of steel (low alloy steel) it would be in order to say that when properly heat treated they combine high ductility with high strength. These low alloy steels also have 30 to 40 per cent higher yield strength, 10 to 20 per cent higher elongation, and sometimes as much as twice the impact strength when compared with carbon steel of the same tensile strength and hardness. Another important characteristic of the low alloy steels as a class is that they have greater hardenability than the carbon steels.

TABLE III

Classification of SAE Low-alloy Steels

SAE series	Composition range, per cent				
	Manganese	Nickel	Chromium	Molybdenum	Vanadium
1300*	1.60 to 1.90	.....	.....	.....	.....
2000	0.30 to 0.60	0.40 to 0.60	.....	.....	.....
2100	0.30 to 0.60	1.25 to 1.75	.....	.....	.....
2300	0.30 to 0.90	3.25 to 3.75	.....	.....	.....
2500	0.30 to 0.60	4.75 to 5.25	.....	.....	.....
3100	0.30 to 0.90	1.00 to 1.50	0.45 to 0.75	.....	.....
3200	0.30 to 0.60	1.50 to 2.00	0.90 to 1.25	.....	.....
3300	0.30 to 0.60	3.25 to 3.75	1.25 to 1.75	.....	.....
3400	0.30 to 0.60	2.75 to 3.25	0.60 to 3.95	.....	.....
4100	0.40 to 0.90	.....	0.80 to 1.10	0.15 to 0.25	.....
4300	0.40 to 0.80	1.50 to 2.00	0.30 to 0.80	0.20 to 0.40	.....
4600	0.40 to 0.80	1.65 to 2.00	.....	0.20 to 0.30	.....
4800	0.40 to 0.60	3.25 to 3.75	.....	0.20 to 0.30	.....
5100	0.30 to 0.90	.....	0.80 to 1.10	.....	.....
6100	0.30 to 0.90	.....	0.80 to 1.10	.....	0.15 min.
9200	0.60 to 0.90	.....	.....	1.80 to 2.20†	.....

HIGH ALLOY STEELS

The high alloy steels, with the exception of the high speed, austenitic manganese and very few others, are of recent development. Most of the work on these materials in this country has been done within the past 30 years. There are several hundred of these steels, which may be divided into approximately 3 general classes:

1. The so-called high speed steels, and high tungsten, high chromium, and tool and die steels.
2. Heat and corrosion resistant steels whose basic alloying element is chromium in amounts between 10 and 30 per cent either alone or with nickel and other alloying elements for specific application.
3. Special steels used for specific applications where magnetic electrical or special expansion characteristics or wear resistance are important.

Tool and die steels—According to Gill (A.S.M. 1934) at least 95 per cent of all of the thousand or more brands of tool and die steels can be divided into 13 general types according to chemical composition. These types and their general characteristics are given in Tables IV and V [10]. Broadly speaking, all tools may be divided into two general classes: cutting and shearing tools, and forming tools. Requirements differ and should be considered before a choice of steel is made for any given tool or die. Thus, for cutting and shearing, high hardness, ability to withstand wear, stability of structure to withstand the heat generated by friction of the cutting edge against the work or from hot shearing, and a substantial amount of toughness to prevent chipping or breaking are necessary.

Forming tools consist mostly of dies which are used to transform their impression to either hot or cold solid metal, or to molten metal (die casting). Tools of this type must be resistant to distortion in heat treatment and to cracking and spalling caused by thermal shock in use, also they must possess the qualities necessary in cutting and shearing tools. The advice of tool steel metallurgists is very helpful in selecting the right tool steel for a given operation. As noted in Table V, tool steels vary widely in properties. To select the proper

TABLE IV

Classification of Tool Steels According to Chemical Composition (Gill)

Type No.	Type	Chemical composition, per cent						
		Carbon	Silicon	Manganese	Tungsten	Chromium	Vanadium	
1	High carbon	0.60 to 1.40	0.15 to 0.50	0.10 to 0.35	.....	.....	.....	
2	Carbon-vanadium	0.60 to 1.40	0.15 to 0.50	0.10 to 0.35	.....	.....	0.10 to 0.40	
3	Low-chromium	0.60 to 1.40	0.15 to 0.50	0.10 to 0.35	.....	0.20 to 1.00	0.00 to 0.20	
4	Oil-hardening manganese*	0.85 to 1.00	0.20 to 0.40	1.00 to 1.75	0.30 to 0.60	0.30 to 0.90	0.00 to 0.25	
5	Silicon-manganese†	0.50 to 0.70	1.75 to 2.25	0.70 to 1.00	.....	0.00 to 0.40	0.00 to 0.30	Tool
6	Low-tungsten	1.00 to 1.30	0.20 to 0.40	0.10 to 0.30	1.00 to 2.50	0.35 to 0.60	0.00 to 0.25	and
7	Tungsten chisel steel	0.45 to 0.60	0.20 to 1.50	.....	0.75 to 2.50	0.75 to 2.00	0.00 to 0.30	die
8	Finishing tool steel	1.20 to 1.40	.....	.....	3.00 to 6.00	0.00 to 1.50	.....	steels
9	Chromium, for hot working†	0.70 to 1.00	.....	.....	.....	3.00 to 4.25	.....	
10	Tungsten, for hot working	0.25 to 0.60	.....	.....	8.00 to 19.00	1.25 to 4.50	0.30 to 1.20	
11	Chromium-tungsten, hot working†	0.30 to 0.50	0.20 to 1.00	.....	0.75 to 7.50	1.00 to 7.50	.....	
12	High-carbon, high-chromium‡	1.40 to 2.45	.....	.....	.....	12.00 to 18.00	0.00 to 1.00	
13	High-speed‡	0.55 to 1.00	.....	.....	14.00 to 21.00	4.00 to 4.50	1.00 to 2.25	

* If manganese is 1.50 to 1.75 per cent, may contain no other alloying elements.
† May contain molybdenum.
‡ May contain cobalt and/or molybdenum.

TABLE V

Characteristics of Principal Types of Tool Steel (Gill)

Type No.	Usual working hardness Rockwell C	Resistance to wear	Toughness	Distortion in heat treatment	Resistance to softening at elevated temperature	Quenching medium	Depth of hardening
1	*	Low	*	High	Low	Water	Shallow
2	*	Low	*	High	Low	Water	Shallow
3	*	Low	*	High	Low	Water	Medium
4	58 to 62	Low	Medium	Low	Low	Oil	Medium
5	50 to 57	Medium	Medium	Medium	Medium	Water	Medium
6	62 to 65	Medium	Medium	Low	Low	Oil	Medium
7	50 to 55	Medium	High	Low	Medium	Oil	Medium
8	63 to 66	Medium	Low	High	Medium	Water	Deep
9	45 to 50	Medium	Medium	Low	Medium	Air or oil	Deep
10	45 to 55	Medium	Medium	Low	High	Air or oil	Deep
11	43 to 50	Medium	Medium	Low	High	Air or oil	Deep
12	58 to 66	High	Low	Low	High	Air or oil	Deep
13	62 to 66	High	Low	Low	High	Air or oil	Deep

* Depends upon carbon content and heat treatment.

steel means to balance undesirable against desirable properties and to take into account not only the cost of the steel and cost of machining, but also, the cost of the finished tool over its expected life. Proper selection will also depend upon design of tool. If the design is such that the tool is likely to crack if quenched in water, then the more costly oil-hardening steel should be chosen in preference to the cheaper water-hardening steel. Most engineers have, in all probability, encountered operations which were similar and requiring tools of same design, yet made from entirely different steels as for example, shear blades. A close study of the previous illustrations and tables give compositions of the steels used, their properties, the working conditions, and may throw additional light upon this problem and enable the metallurgical department to specify a tool steel that would be satisfactory for both operations and eliminate

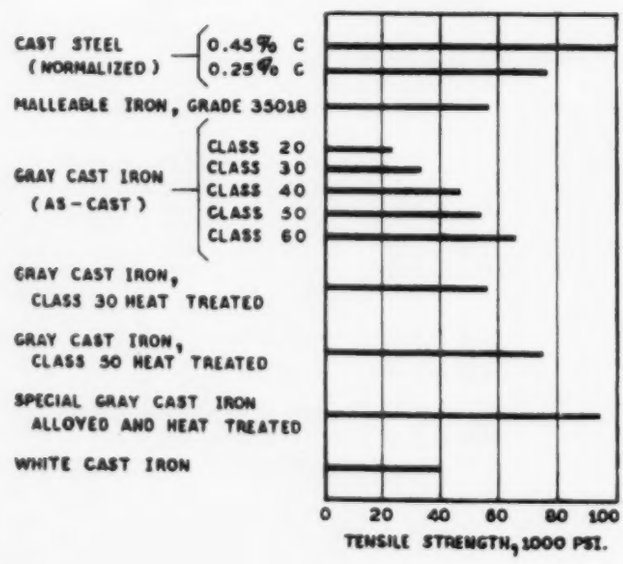


Figure 12 — Relative tensile strength of several cast irons and steels.

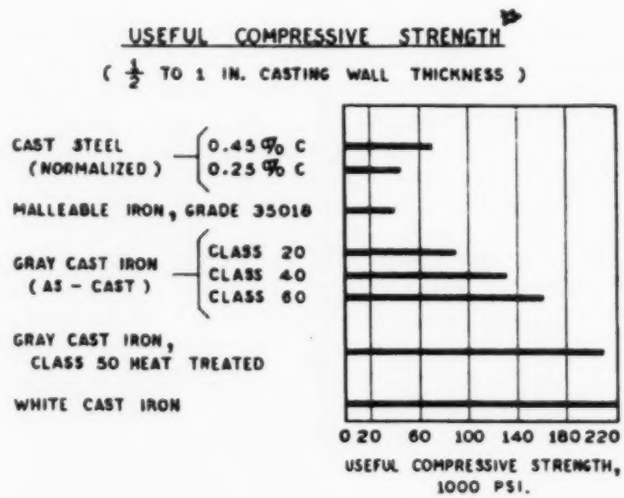


Figure 13 — When pure compressive forces are present without tensile components, gray iron in all classes is much stronger than cast steel.

the necessity of having to change blades each time operations change.

Heat and corrosion resistant steels (stainless steels)— In general, steels of this type may be classified into three main groups, depending upon their microstructure (with the exception, of course, of the so-called super-alloys).

1. The hardenable alloys, which are pearlitic when annealed and martensitic when quenched.
2. The non-hardenable, magnetic alloys, which are ferritic.
3. The non-hardenable, non-magnetic alloys which are austenitic.

Groups 1 and 2 are essentially chrome, iron alloys, whereas Group 3 are chrome, nickel iron alloys. Although this group cannot be hardened by heat treating, high strength can be obtained by proper cold working.

The corrosion resistance of these steels is one of their

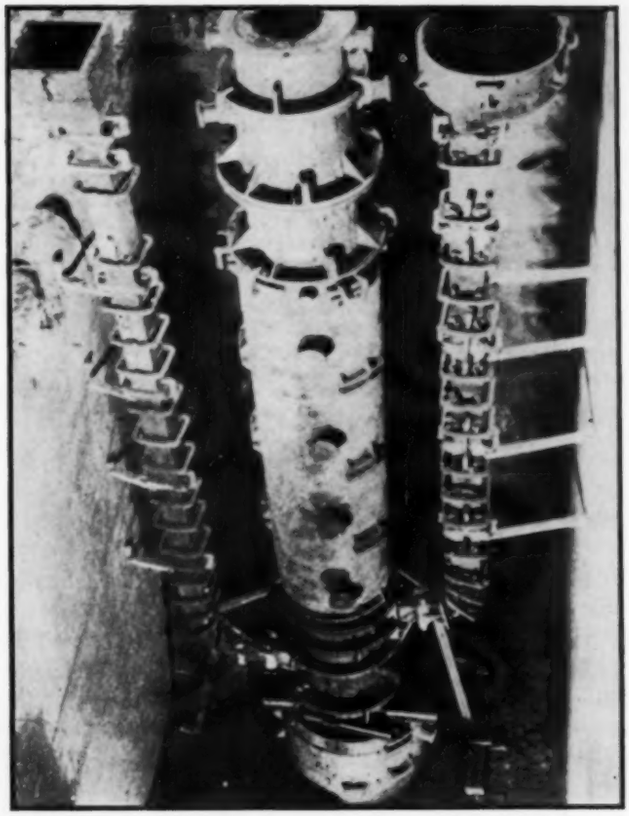


Figure 14 — Pouring pit and assembled mold ready for pouring. The mold is for a large plate mill iron roll.

most important characteristics. Experience has taught that the specifications for the selection, treatment, method of fabrication of a given stainless steel part or structure to withstand a particular corrosive environment should be left up to the metallurgical department and those who have specialized in the study of the uses and properties of these steels. In a good many cases it has been found that the problem could only be solved by trial. The mechanical and technological properties of the wrought stainless steels have always been of importance to the steel mill, but I think certain of their engineering properties are of equal importance and will increase in value in the future. This is especially true in engineering structures where strength and corrosion resistance are required. Almost any handbook giving the heat and corrosion resistant properties of metals, as well as corrosion fatigue and notch fatigue properties, indicates that certain types of these stainless steels are outstanding in this regard. Referring back to Figure 7, the maximum corrosion fatigue endurance limits of the corrodible alloy steels varied between 15,000 and 25,000 psi, which ranges from 6 to 60 per cent of the fatigue endurance limit of these steels when based upon tests conducted on polished specimens, the lower percentage being for the higher strength steels. On the other hand, the fatigue corrosion endurance of the stainless steels (that is, in corrosive conditions to which they are really resistant) will range from 70 to 90 per cent of their endurance limits for polished specimens (when properly processed). The austenitic stainless steels have exceptional notch-fatigue properties which could possibly be taken advantage of in a good many applications in steel mill maintenance, such as bolts which have to be replaced frequently due to fatigue failure or corrosion fatigue failure in threaded section of bolt. The heat resistant properties of these alloys, especially the higher nickel such as 65-15, 35-15, 25-12 and 18-8 and others are well known. There are, no doubt, numerous places in the steel mill, especially re-heating furnaces, soaking pits and heat treating furnaces where steels of this type are being used or could be used to definite advantage.

Special steels—The steels in this group vary widely in composition and are lumped together for convenience in discussing them. They are used for specific applications where unique magnetic and electrical properties, or special expansion characteristics or some other properties are required. They are of primary interest to the electrical, communication and process control engineer. Table VI gives a few of these alloys which have made possible the efficiency of modern electrical equipment, precision instruments, long distance telephone communication and radio. Invar and superinvar and similar alloys are used in parts of machinery and instruments which must remain constant in dimension despite temperature change. Elinvar and similar alloys are used for hairsprings of watches and other precision instruments which require metal of a constant modulus of elasticity when subjected to varying temperature (in the vicinity of room temperature). Permalloy, Hipernik, Perminvar and similar alloys are used in places where high magnetic permeability is required, as in certain parts of communication equipment. The efficiency of radio loud speakers and other equipment requiring powerful permanent magnets has been greatly increased by the development of such alloys as the Alnico group, Vicalloy, Cunico and Comol. Then there are the electrical sheet steels which are essentially high quality, low carbon, silicon steels with silicon varying between 1.00 and 6.50 per cent. This group of steels makes possible the high electrical efficiency of modern day transformers, motors and generators.

CAST IRON

The engineering properties of gray cast iron have taken on added significance in the past 20 years. It has changed from being classified as a material whose prin-

Figure 15 — The roll being poured in this picture will be 28 in. in diameter, have an overall length of 14 ft and weigh approximately 16 tons.

TABLE VI

Commercial High-nickel Alloys

Name	Composition,* per cent						Characteristic properties
	Ni	Co	Cr	W	Al	Cu	
Invar	36	..	..	..	..	..	Low expansion from 0 to 200 F. (—18 to 100 C.)
Superinvar	31	5	..	..	..	..	Zero expansion near room temperature
Elinvar	32	..	5	2	..	..	Low thermoelastic coefficient
Dumet	42	..	..	..	..	..	For sealing in soft glass
Kovar	29	17	..	..	..	..	For sealing in hard glass
Platinite	46	..	..	..	..	..	Expansion same as platinum
Permalloy	78.5	..	..	..	..	..	High permeability at low field strengths
Hipernik	50	..	..	..	..	..	High permeability at higher field strengths
Perminvar	45	25	..	..	..	..	Constant permeability over a range of flux densities
Alnico I	20	5	..	..	12	..	Permanent magnet of high magnetic hardness
Alnico II	17	12.5	..	..	10	6	Same as above
Alnico III	25	..	..	..	12	..	Same as above
Alnico IV	28	5	..	..	12	..	Same as above

* Balance of composition is mostly iron.

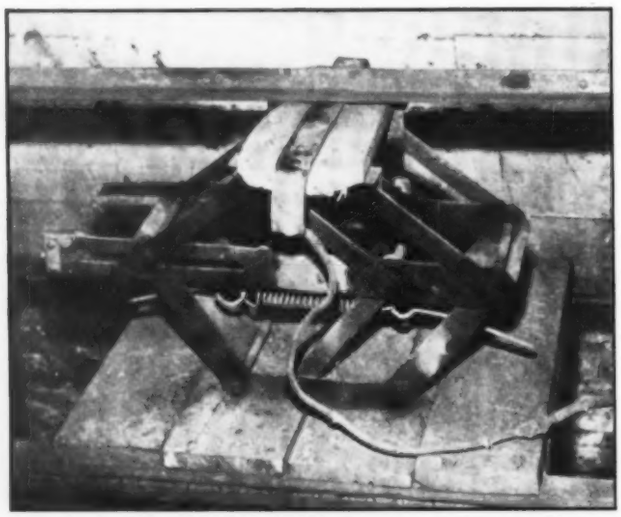
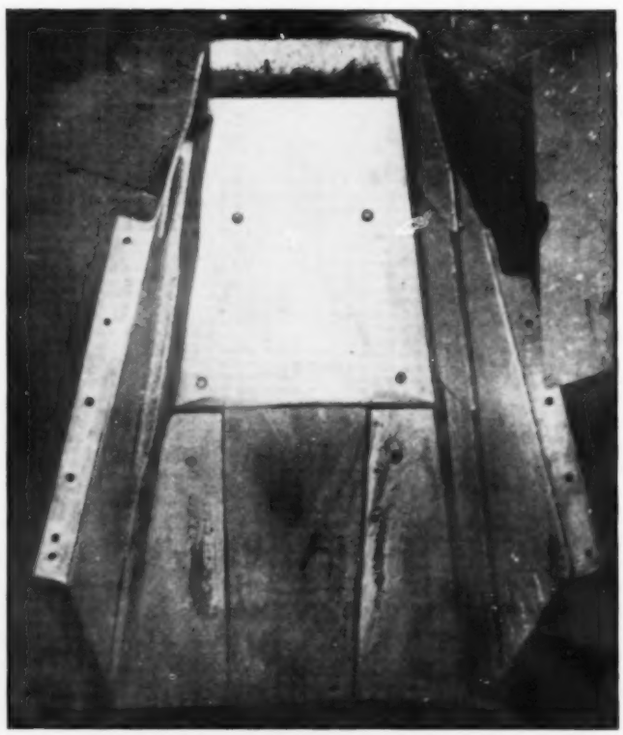


Figure 16 — Contact shoe for mix car is cast of high chrome iron containing 26 to 27 per cent chromium, 2.6 to 2.8 per cent carbon. This chrome iron contact shoe has a service life of approximately 10 years. Tool steel in similar service is said to wear out in 3 to 4 months, copper in 24 hours.

cipal attributes were cheapness, ease of casting into shape and ready machinability to become an important engineering material whose composition, structure and properties are carefully controlled in the better foundries. Metallurgically speaking, gray iron can be broadly called steel plus graphite. That is how it appears under the microscope. The graphite occupies 11.00 to 17.00 per cent of the volume of metal, depending upon composition of metal, design of casting and control of casting conditions. By controlling the size, distribution and amount of graphite flakes, by alloying or inoculating, almost any desired tensile strength between 10,000 and 70,000 psi can be produced in the metal as cast. In certain compositions and castings that will lend themselves to heat treatment, strengths as high as 95,000 psi tensile have been obtained. Figure 12 gives relative tensile strength of several cast irons and steels. In compression gray cast iron is much stronger than steel. This is shown in Figure 13. The modulus of elasticity of gray iron is between 12 million and 22 million psi, depending upon tensile strength, amount and distribution of graphite. The theoretical endurance limit of gray iron is between 35 and 50 per cent of the tensile strength. This metal is much less notch sensitive than steel. In a previous figure it was shown that the endurance limit for notch specimen of steel was between 30 and 50 per cent of the endurance limit for polished steel specimens. However, according to published data in the Cast Metals Handbook, the endurance limit of severely notched specimens of cast iron ranged between 70 and 100 per cent of the endurance limit for polished specimens. Gray iron has greater damping capacity than steel. That is, it has greater ability to absorb or

Figure 17 — Spout for outlet end of chute handling abrasive materials has chrome iron liner plates similar in analysis to that in Figure 16. These chrome iron plates last 13 to 21 times longer than ordinary steel plates. The plate in the center showing a worn spot has been in service 10 years.



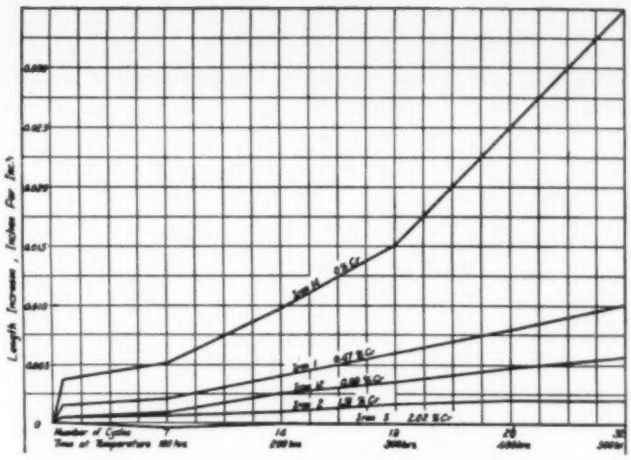


Figure 18 — Typical curve of growth with increasing time at temperature for plain and chromium bearing iron. It can be seen that there is a decided decrease in growth as chrome content increases.

dampen out vibration. In sliding friction where seizing and galling is a problem, cast iron is outstanding.

Most engineers are familiar with a good many of the applications of cast iron in the steel industry for such parts as compressors, cylinders, pistons, housings, frames and beds for machine tools, gears, dies, molds, rolls, shoes, guides, grate bars and many others. Figures 14 and 15 show the casting of a roll from this type metal. The roll being poured in Figure 15 will be 28 in. in diameter, have an overall length of 14 ft, and weigh 16 tons.

There are no doubt many other applications where this material, properly alloyed to resist abrasion, or corrosion or deterioration at high temperatures would give excellent life. For example, excellent resistance to abrasive type of wear can be obtained with the 27 per cent chrome iron, nickel chrome iron or chilled cast alloy iron, see Figures 16 and 17. Excellent resistance to growth at high temperature can be obtained by alloying with chrome alone or in combination with nickel, molybdenum and silicon. See Figure 18. This property of the alloyed iron is used to advantage in grate bars, stoker and other furnace parts, as well as melting pots for nonferrous alloys. We do not mean to imply that cast iron can replace steel castings, especially of the higher alloy, heat resistant types where their use is indicated, but we wish to stress the economical importance of the right application of materials to give maximum service life for any given part or casting under a given set of conditions.

For additional information on the engineering properties of cast metals of all types reference is made to the Cast Metals Handbook. This handbook gives up-to-date authoritative information of the type desired by the designing engineers on most types of cast metals.

In conclusion, the importance of the mill metallurgical, maintenance, and engineering departments functioning as a team should be stressed, especially in solving all problems pertaining to the failure of metal parts, regardless of whether failure was due to fatigue, wear, corrosion or abrasion. Too often the necessity of replacing certain parts is taken for granted, and we fail to realize the economic loss incurred in this practice.

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DISCUSSION

PRESENTED BY

ROBERT M. SCHRODER, Great Lakes Steel Corporation, Ecorse, Michigan

VAL VERDI, First Helper, Open Hearth Building, Ford Motor Company, Detroit, Michigan

W. B. McFERRIN, Metallurgical Engineer, Electro Metallurgical Company, New York, New York

E. W. CONNOLLY, Service Engineer, Detroit District Office, Haynes Stellite Company, Detroit 2, Michigan

N. E. ROTHENTHALER, Chief Metallurgist, Ford Motor Company, Dearborn, Michigan

R. E. CRASSWELLER, Great Lakes Steel Corporation, Ecorse, Michigan

W. E. HART, Superintendent, Electric Furnace Building, Ford Motor Company, Dearborn, Michigan

W. H. COLLISON, Coke Plant Superintendent, Great Lakes Steel Corporation, Ecorse, Michigan

Robert M. Schroder: It is interesting to note that we of the Great Lakes Steel Corporation metallurgical department have, during the past two years, come to recognize the facts which Mr. McFerrin has so ably brought to our attention. We have been striving to give more definite help to our mechanical mill maintenance in solving many problems which arise. In the beginning we came to recognize that it seemed rather odd and almost ridiculous that we should maintain a group of service or contact metallurgists with a view to always keeping abreast of and spending many hours in helping to solve our customer's fabricating, maintenance, and metallurgical problems when at the same time we paid little or no attention to the many thousands of dollars which were being spent each month in our own mill's maintenance shops.

We are now, therefore, giving increasing attention to the metallurgical problems arising in our own mill maintenance, and although we have just begun in this work, we find that it has already paid dividends.

Even at the present time we are formulating a program whereby a group of properly delegated metallurgists will obtain complete blueprint and fabricating information on our mechanical maintenance parts.

Furthermore, we then hope to actually recommend types of steel, proper heat treatment and carburizing where necessary, and other metallurgical advices for each and every maintenance job. We hope to find that several properly selected analyses of our own X9100 series steels will take care of the majority of our maintenance problems, and if so, these analyses will be rolled, properly marked, and then recommended to be used where their advantages will be the greatest.

We know, from our experience along this line so far, that such a procedure if properly supervised and followed through will definitely save our company many hours of useless maintenance and replacement work and certainly will also save money.

If Mr. McFerrin's paper only serves to bring to the minds of those concerned that a very definite metallurgical problem does exist in all large plant maintenance, it will then have served a most useful purpose.

With respect to the contents of this paper, the writer would like to ask Mr. McFerrin if the guides which he stated had been hard surface welded using the Group B nickel base alloys and which reportedly lasted four times as long as high alloy steel guides, ultimately failed as a result of wear, or was the failure due to lack of toughness in the base metal of the guide? Furthermore, do these Group B nickel base alloys contain any iron as an alloying element?"

On the subject of hard surface welding and other types of welding, the writer believes that it is also pertinent to mention that especially in the cases of large sections and where the base metal to be welded may contain fairly high carbon and appreciable alloy content that the welding procedures must be closely watched. Often times the advantages gained are completely lost through improper application or lack of preheat and/or postheat which may be necessary to prevent weld bead cracking, under bead cracking, or parent metal cracks. Such cracking may be only initiated and not even visible to the surface observer, but if present will often make the maintenance or repair job completely useless if the part is to be subjected to dynamic stresses. This is in line with Mr. McFerrin's explanation of the detrimental effects of sharp fillets, notches, and other stress raisers. In most cases preheating properly before welding large steel sections is not only necessary but makes the differences between a completely satisfactory job and one which is useless. Postheating after welding is also very advantageous, but usually is not as satisfactory as preheating before welding, since in many cases weldment cracks or parent metal cracks are often initiated before a postheat treatment can do its job. Preheating greatly lowers the cooling rate after the deposition of the weld metal and such will almost always prevent trouble—this of course providing proper welding rod and techniques have been used in the operation.

The writer also believes it worthwhile to note where Mr. McFerrin stated that when notches are present, the behavior differs both with notch and with the steel, and here it may be added that the behavior is also dependent upon the section size under, or effected by, a given notch. In other words a notch of given sharpness or radius at the base would actually cause a greater stress concentration in a large section as compared with a small section. The standard notch in a small laboratory fatigue specimen will result in some definite stress concentration. The same notch in a large railroad axle, for example, would result in appreciably higher stress concentration. This does not mean that a large railroad axle with a given notch is not stronger than a small bolt or fatigue specimen with the same notch, but it does mean that under their respective loads this notch will have a more deleterious effect on the larger section. This is important to those in the machine shop where often they feel that a tool mark, scratch or sharp fillet on a large section means nothing, whereas often times they try to eliminate such defects in small sections—actually the reverse would be the safer procedure and the Utopia would be to try to eliminate definite tool marks, scratches and sharp fillets in both large and small sections which will be stressed under either dynamic or static loads.

Val Verdi: Why is it that gray cast iron is very superior to cast steel? You said that endurance strength of gray cast iron endurance is better than cast steel, but I overlooked the reason why.

W. B. McFerrin: Gray cast iron is only superior to cast steel for certain applications. Gray cast iron is less notch sensitive than cast steel. Cast steel may be caused to fail with a brittle fracture if stress is concentrated on a notch, but because of the random distribution of graphite in a properly made engineering gray cast iron, sudden stress cannot travel along a single plane or in a straight line, but will be diffused and distributed in many directions, and unless very severe, will not induce cracks at a localized point and so cause failure.

The compressive strength of gray cast iron is much higher than most cast steel (this was illustrated in Figure 22). Gray cast iron has excellent damping capacity. The energy it is capable of absorbing per cycle is in the range of 8 to 10 times that of steel. This property is taken advantage of in the construction of large machine tools, also, in crankshafts for diesel engines and some automobiles. In sliding friction gray iron is outstanding. This is demonstrated by the fact that practically all machine tool ways and, in some instances, gears and bearings, also, engine cylinders, piston rings, clutch plates and brake drums are made from gray cast iron. I do not mean to imply that gray cast iron can replace cast steel. Every material has its place.

Now with regard to Mr. Schroder's question. These guides were hard surface welded using a Group B nickel base alloy. The hard surface material was applied in a very thin layer, and the material work hardened in service. Replacement was necessary due to wear. In other words, the parts merely had to be resurfaced again. Now for the exact composition of this particular alloy I would like to call on Mr. Ed Connolly.

E. W. Connolly: The material used was a low carbon nickel base alloy containing additions of approximately 15 per cent chromium, 15 per cent molybdenum, 5 per cent tungsten and 5 per cent iron.

N. E. Rothenthaler: Along with the maintenance department of the Ford Motor Company, we have of course a large metallurgical organization which is con-

sulted by our maintenance men throughout all the operations in the Ford Motor Company. Consequently, we have many research operations for application of new alloys or new metals.

During the war, we had some very interesting developments principally in armor plate. In 1941 the Ford Motor Company negotiated with the United States Army a large tank contract, and it was decided to process all of the armor plate required for this vehicle from the open hearth through to the final assembly. At that time, very little was known of armor plate processing. We decided to apply modified Ford alloy containing chromium and molybdenum for this homogeneous armor plate.

After developing satisfactory ballistic properties of this high alloy steel, we then purchased the necessary heat treating equipment. However, in a very short period of time, we were authorized to reduce the alloy content of this steel for conservation purposes, and consequently, we had to institute further research on lower alloy steels for the same application.

We again developed a lower alloy steel which was satisfactory for armor plate. Along with the development of the alloy, we designed a special quenching procedure which would eliminate the straightening of the armor plate after heat treatment.

At that time approximately 24 hours was necessary for the straightening of one set of plates for a tank. With the required volume of vehicles necessary for our war effort, this time was excessive. Therefore, our quenching process permitted us to fabricate the heat treated armor plate without the subsequent straightening.

The armor plate was quenched under die pressures to prevent distortion or warping. The original platen dies were satisfactory for light plates from ¼ to ¾ in., however, the heavier plates from 1 to 3 in. were not satisfactorily quenched by this method and we redesigned the platen fixtures for a direct quenching under pressure which was used throughout the remainder of the war period.

Again in 1943, we were authorized from Washington to reduce our alloy steel further. In order to compensate for depth of hardenability, we used boron as an intensifying agent to compensate for reduction of molybdenum. We used up to 0.003 per cent of boron which gave us approximately an equal ratio of hardenability for 0.15 per cent of molybdenum. However, on the heavier plates, we could not reduce our molybdenum because of the hazard of temper brittleness.

Several other interesting developments in the sheet steel industry was the use of deoxidizers for stabilizing steel so as to retard age hardening characteristics. Of recent development is the use of vanadium which permits rimming action and decelerates age hardening.

The use of high tensile steels is more prevalent today as a means of conserving metal by applying lower gage sheets with the same or increased strength on auto body parts.

It is interesting to note that sheets of Rockwell Hardness B75 can be drawn to some of the shallower fender shapes. This metal has been used satisfactorily for several thousands of fenders to date.

R. E. Crassweller: I might add that we are going along more or less on a working plan with the men out in the mill. The laboratory follows along with the plan, in that, if any part breaks or fails, the mill men come to us and we give them all the help we can. We found that with the proper application of heat treatment we have eliminated considerable replacement and saved a lot of work as far as the machine shop is concerned by giving them more time to devote to some other job that might be more necessary or more pertinent to get out. In one instance where we had been using roller pins on the big mill, we had trouble for a while in breakage of the pins; and we found that by hardening them or using steel with a little alloy so that we could get some hardness, we have been able to make them last a lot longer. Where we had been replacing about 90 to 100 or so of the pins a year, their replacement was cut down to about 42. So, in that way, every little place that we can help out the amount of rolling time is increased and the down time is considerably lower.

In the same way we work with the men in the cold mill to help them keep the mill in operation by aiding in part replacement wherever we can. We have a small unit in the laboratory where we can heat treat the parts and help out consideraby in cutting down the amount of replacement that has to be made throughout the mill. We find that it is always advantageous to put in an alloy, and to change the type of steels in a lot of cases to help out their operations.

W. E. Hart: Some years ago I had considerable experience with roll making without too much success. I wonder if you would elaborate a little on tapping and teeming temperatures, also types of furnaces used by the roll making industry, and the methods used by the furnace operator to check his melt before tapping?

W. B. McFerrin: I think you are in a much better position to elaborate on the actual control of melting process, especially for those metals which are melted in the basic electric. However, the composition of rolls will generally be in the following range, depending upon the type of roll.

ROUGHING ROLLS

(Alloy steel)

Carbon	0.50 to 1.20 per cent
Chrome	0.70 to 1.25 per cent
Nickel	Residual to 3.5 per cent
Molybdenum	0.35 to 0.50 per cent
Vanadium	0.15 to 0.20 per cent
Silicon	0.30 to 0.70 per cent
Sulphur	0.02 to 0.04 per cent
Phosphorus	0.015 to 0.08 per cent

CHILLED ROLLS

Total carbon	2.50 to 3.50 per cent
Chrome	0 to 2.25 per cent
Nickel	0 to 4.50 per cent
Molybdenum	0 to 1.00 per cent
Vanadium	0 to 0.35 per cent
Silicon	0.75 to 1.25 per cent
Sulphur	0.05 to 0.15 per cent
Phosphorus	0.05 to 0.30 per cent

GRAINED ROLLS

Total carbon	2.50 to 3.35 per cent
Chrome	0 to 1.00 per cent
Nickel	0.15 to 2.25 per cent
Molybdenum	0 to 0.75 per cent
Vanadium	0 to 0.25 per cent
Silicon	0.70 to 1.25 per cent
Sulphur	0.035 to 0.07 per cent
Phosphorus	0.10 to 0.30 per cent

Practically all cast rolls for the steel industry are poured on end as illustrated in previous slide. Steel rolls are generally poured from a bottom pour type ladle and poured similar to the method used in top pouring an ingot. The pouring temperature of the metal for steel rolls is generally between 2800 and 2850 F. Metal for steel rolls is generally melted in the acid open hearth or electric furnace. However, basic open hearth steel has been used. Metal for iron rolls (grained and chilled cast rolls) is generally melted in the air furnace. However, some of the higher carbon compositions have been melted in the cupola. Generally, in pouring iron rolls, a lip type pouring ladle is used and the roll is gated at the bottom, the gate entering the bottom of the mold tangent to the circumference of the roll. This method of gating will produce a casting freer from surface defects and other imperfections. This method of gating is also used quite often to pour steel rolls. The pouring temperature of the metal for iron rolls is generally between 2500 and 2700 F.

W. H. Collison: Most of the discussion so far has been either metallurgical or mechanical. In the coke plant, where some problems are similar to a chemical plant, corrosion is a problem and an item adding considerably to the cost of plant maintenance. Our coke plant is located in a highly industrialized area and is unusually close to the blast furnaces. At various times we suffer one or more of these: fly ash, blast furnace flue dust, soda ash dust, more than normal amounts of carbon dioxide, and traces or more than traces of sulphur dioxide, hydrogen sulphide, sulphuric acid fume, chlorine gas and ammonia. Maintenance of structural steel, steel sheeting, steel doors, etc., is difficult and expensive in such an atmosphere, even though painted. I doubt if anyone can offer us much help with this problem.

Perhaps more help can be offered in the case of heat exchanger tubes, where weak ammonia liquor containing hydrogen sulphide, hydrogen cyanide and some other compounds of sulphur, nitrogen, ammonia and oxygen, cause a pitted type of corrosion, especially at temperatures near the boiling point of water. Steel coke oven gas mains in the immediate vicinity of boilers or mill furnaces suffer much the same corrision. Needed in these applications is a steel which can be rolled into place in a tube sheet, which will have better life, and which is not expensive. The last may mean that it must be a low alloy rather than a high alloy steel.

A. J. FISHER WINS AISE KELLY AWARD

The 1947 prize winning Kelly Award papers were made by the board of directors at their annual meeting on September 27, 1948. A. J. Fisher, assistant chief engineer of construction, Bethlehem Steel Company, won the first prize for his paper, "Recent Improvements in Cover Annealing," which was published in the April 1947 issue of the *Iron and Steel Engineer*. This paper, which discussed an installation at the Sparrows Point plant of the Bethlehem Steel Company, has aroused a great deal of interest. Mr. Fisher also won the first Kelly Award which was given for the year 1943 for his paper, "Relation of Flame Character to Open Hearth Operation."

Second place was given to E. T. W. Bailey for his paper, "Oxygen-Accelerated Combustion in Open Hearth Furnaces," which was published in November 1947. Mr. Bailey was one of the pioneers in the development work in the use of oxygen in the open hearth, and this paper was one of the first reports outlining the results of this practice. Much of the later experimental work has been guided by the results outlined in this paper.

Third place in the award was given to the perennial winner, Ross E. Beynon for his paper "Rod Mills and Rod Mill Design" which was published in the June 1947 issue of the *Iron and Steel Engineer*. Mr. Beynon has thus won a prize for five straight years, and has not missed receiving one of the awards since the contest was started in 1943. Mr. Beynon won first place for the years 1946 and 1944; he won second place for the years 1945 and 1943.

The Kelly Award carries prizes of $300, $200 and $100 for first, second and third places, respectively. The award was established September 28, 1943 to honor John F. Kelly, managing director of the AISE from 1917 to 1934, and to perpetuate the memory of his achievements in the advancement of the Association.

The award is made each year by the board of directors of the AISE upon the recommendations of the editorial and executive committees of the Association.

Rules of the Award:

1. The Award shall be given annually to the author of the paper, adjudged of greatest value in the advancement of engineering or operating practice in the iron and steel industry.
2. The entries for each judging shall be the papers published in the *Iron and Steel Engineer* during each calendar year, although some may have been presented at meetings in the previous year. Voluntary contributions of papers not presented at meetings but published by the Association are also included in the judging.
3. To be eligible for the Award, the author must be directly employed in the iron and steel producing industry. The author need not be a member of the Association of Iron and Steel Engineers.
4. The Award shall be made at the Annual fall meeting following the close of the calendar year.
5. The Award shall be made by the board of directors of the Association on the recommendation of the executive committee of the Association.

POWER FOR AN INDUSTRIAL PLANT

. . . . whether to purchase or generate power is a problem which can be decided only after a thorough study of the requirements of the plant concerned . . . .

STEAM

By E. M. YARD, Staff Engineer
John A. Roebling's Sons Company
Trenton, New Jersey

▲ PLANT utilities should be re-examined periodically to determine whether continued operation, alteration, addition, or replacement is required for maximum plant economy. Changes in plant load, relative costs of labor and fuel, maintenance expense, obsolescence of equipment, plant expansion, etc., may be factors in deciding to check the economy of utilities.

The first part of this paper will deal with such a re-examination of the steam generating equipment at the Roebling Company and its results. The second part will cover the same problem for our electric generating utilities.

The major factors, in our case, which led to an investigation of our boiler house was obsolescence of equipment. Symptoms of this were:

1. High steam cost.
2. High maintenance.
3. Difficulty in handling peak loads.

Our boilers were in two adjacent buildings. Eight were fired with pulverized coal, four were fired by Wetzel stokers, all twelve were sectional header water tube boilers of 500 hp each. The pulverized coal firing on eight boilers was the result of an investigation of about ten years ago. The conversion was made without installing water walls, and, while higher ratings and efficiencies were attained than with the Wetzel stokers, these units were not capable of sustaining the loads placed upon them during the war and since, with anything like a tolerable efficiency. Excessive maintenance resulting from forcing these units contributed to a low availability and occasional inability to carry the plant load.

Our study showed low efficiency of the boilers as the principal element in high steam costs. Labor and maintenance costs followed in that order. We found an average efficiency of 60 per cent annually for all twelve units. Since our yearly coal consumption ran to 50,000 tons, the fuel savings possible were considerable.

It was clear that a new steam generation plant was probably justified, and our study was extended to discover what should be done.

There are always several possible alternatives:

1. Modernize existing equipment as by oil firing, installing water walls, etc.
2. Supplement old equipment with new boilers.
3. Replace the old plant.

In our case the poor condition of our boilers ruled out the first alternate. The second and third were studied, but since the second was unlikely, for the same reason of poor condition of existing boilers, the study concentrated on the third plan. This ultimately proved most economical, largely because it required the least labor, and had lower operating costs.

In order to provide a new steam generating station for an industrial plant the following things must be determined in the order of their relative importance:

1. Steam load and load variations.
2. Steam temperature and pressure requirements.
3. Sources of fuels and their relative costs.
4. Sources of feedwater and the water characteristics.
5. Degree of reliability required.

From this information the new plant preliminary specifications can be arrived at. These are:

1. Maximum capacity of the plant.
2. Steam pressure and temperature.
3. Number of units, size of each unit, efficiency of units.
4. Primary fuel and method of firing. Secondary fuels if any.
5. Type of feedwater treatment.
6. Type of auxiliaries.

Having outlined the steps in arriving at preliminary specifications, let us follow this through for our own plant. Referring to Figure 1, our steam loads are seen to vary with season and plant operation. Normal winter day loads being 175,000 lb per hour, and idle or heating loads being 100,000 lb per hour. Summer idle loads are 30,000 lb per hour or less. Winter peak loads are 200,000 lb per hour or slightly over. From a study of this data we were able to set down the conditions shown in Table I:

Presented before AISE Philadelphia District Section Meeting, March 6, 1948

TABLE I

Minimum load	20,000 lb per hour
Summer idle load	30,000 lb per hour
Summer operating load	112,000 lb per hour
Winter idle load	100,000 lb per hour
Winter operating load	175,000 lb per hour
Maximum load	205,000 lb per hour
Max feedwater heating steam	35,000 lb per hour
Max total steam	240,000 lb per hour

These are current requirements.

Future plant loads must be considered when new equipment is being purchased. These are purely conjectural. It is, however, true that heating loads gradually increase. So do process loads. Conversely drive loads decrease, and the two approximately balance each other. Future loads will probably be much the same as those today and total capacity is not likely to vary materially. In our case, at least, we felt we could design to meet present loads with reasonable assurance that we could meet the future load.

We knew therefore that a capacity of 240,000 lb per hour was required. We felt that a minimum load should not be less than 25 per cent of a unit capacity for efficient operation. Referring to our minimum load of 20,000 lb per hour and multiplying by four gave us a maximum desirable unit size of 80,000 lb per hour. Three units would supply the total capacity.

The question of a spare boiler was decided negatively. We believed that the high availability of modern steam generators and the small percentage of operating time requiring peak outputs did not justify spare units. Allowable overloads would allow any normal operating load to be carried on two boilers.

The boiler pressure and steam temperature must be adequate to meet plant needs, and in addition may be higher than plant needs in order to allow for power generation with a bleeder turbine. This portion of the paper will refer only to those phases of the question which affect the boiler choice.

It should be clear that the added cost of a high pressure, high temperature plant is not usually great compared to the possible value of an extraction turbine, and no boiler installation should be made for low pressure until the question has been fully investigated.

The exact steam temperature and pressure to be chosen depends on such a variety of factors that no simple rule can be stated or course charted. From the boiler house point of view, the cost of piping and the difficulties of feedwater treatment are major factors. Probably 650 psi pressure and 750 F total steam temperature represent an economical limit where high percentages of makeup water, common to industrial plants, and initial costs are factors. In our case this proved to be the best steam condition.

In this area fuel oil costs about 30 per cent more than bituminous coal per Btu. Natural gas is not available, and waste fuels such as blast furnace gas are not produced in our plant. Anthracite was ruled out for source reasons as a primary fuel. Bagasse, lignite, peat, etc., do not occur in our market. Our fuel choice was clearly bituminous coal, and our experiences with fuel oil this winter makes us doubtful of our decision to consider it a secondary one.

We chose to fire the coal pulverized, believing this to give us as wide a choice of coals as practical, the greatest flexibility in meeting variable loads, the best combustion efficiencies, and the most satisfactory arrangement for alternate firing with fuel oil. We believed any form of stoker or traveling grate undesirable because any breakdown causes a boiler outage, because a change to oil fuel normally requires a shutdown to provide grate protection, and because their inability to withstand air temperatures above 350 F means a reduced efficiency, or the use of an economizer. Two pulverizers per boiler were specified to provide ample flexibility and reliability.

We specified a boiler test efficiency of 86 per cent with air heater but without economizer. This figure is about par for the course today with pulverized coal. A check with alert operators on similar installations showed they attained 84 per cent in average operation. We used 82 per cent in calculating savings.

Our plant has no condensate return system. One is contemplated as part of this project. Eventually as much as 30 per cent of the feedwater may be condensate. Thus makeup will range from 70 to nearly 100 per cent. Obviously feedwater treatment is indicated.

Our water supply is the Delaware River which at times is quite turbid, but usually relatively soft. A hot process softener using phosphoric acid and sodium hydroxide was chosen. This offered the minimum of equipment, the most flexibility, and the softest water. The choice was made after a rather thorough study of available equipment. The base exchange systems were rejected because they are not so flexible in a given installation, require more equipment, and do not always produce as soft water or water as low in total solids. This is a close choice. The hot lime soda process was discarded as not producing water soft enough. Phosphoric acid was chosen as the reagent instead of phosphate salts because it offered a means of reducing total solids, compared to the salt, and of reducing carbonates and thus CO_2 in the steam.

The type of auxiliary drives chosen depends on the heat balance of the plant. By heat balance, we mean the formal accounting for all of the heat that enters the boiler house in the fuel. The purpose of making a heat balance of a plant is to determine whether the energy available could be used in such a way as to produce more work or more steam by rearrangement or readjustment of the parts of the system. With a new plant it might be supposed that a heat balance equal to the theoretical ideal could be attained. This is not so, because there is only limited freedom in the design.

Therefore, the heat balance becomes a compromise which attempts to meet the particular conditions within economic limits. The heat balance of our plant is bound up with the generation of power to a great extent.

In any steam boiler house the feedwater should be heated. This reduces the work of the boiler and is good operating practice. Steam is normally used for this purpose. However, low pressure steam is all that is needed, and this gives us a chance to expand it in a turbine and obtain work. With fans or generators to drive, the work is readily absorbed. The heat energy so used in heating feedwater is transferred between boiler, turbine, and

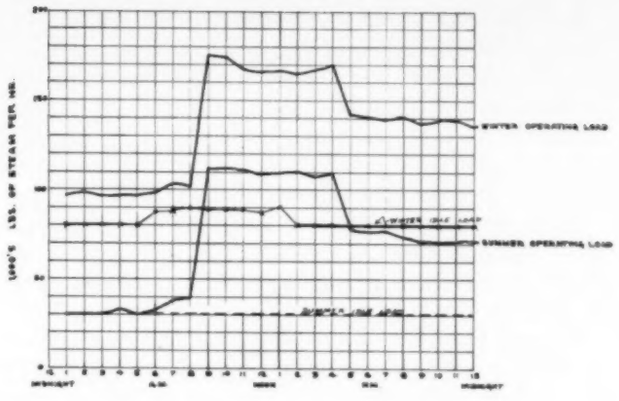

Figure 1 — The figure gives a representative day steam load for the Roebling, New Jersey plant.

feedwater heater. As will be shown later we get the work for its equivalent in Btu's which is less than any other scheme requires.

That is why steam prime movers are desirable in the boiler house. They should be present in sufficient capacity to supply all of the usable feedwater heating steam. Our picture was complicated by presence of a turbo-generator and by an extremely variable plant steam load. This made an ideal heat balance practically impossible for all conditions.

As nearly as we could figure it, turbine drives on our induced draft fans, dual drives on our feedwater pumps and electric drives on our forced draft fans and pulverizers offered the best returns. An average load feedwater heating steam, not supplied from the above steam driven boiler house auxiliaries, is made up from the turbine extraction with an increase in power generation. On paper, dual drives on every major auxiliary would show an advantage, assuming that the type of drive were changed to meet each condition. We felt, however, that the first cost, installation and maintenance costs of extra drives, the complication of controls, and the difficulty of keeping adjusted to our load variations, would offset any gain.

We have shown how we decided to build a new plant, how we decided the size and number of boilers, the fuel and method of firing, and the auxiliary drives. We can now describe the resulting plant.

We have three 80,000 lb per hour boilers, rated 90,000 lb for two hours, 650 psi pressure, 750 F total temperature. These are completely water-cooled, integral furnace, two drum water-tube boilers. They are equipped with air heaters, dust collectors, forced and induced draft fans.

Two pulverizers and two burners fire each boiler. Combination burners are arranged to use Bunker "C" fuel oil as an alternate.

The boilers are equipped with plain and bi-color water glasses, automatic feedwater regulators of the direct operated type.

Combustion control is pneumatic balance, electric drive, and is completely automatic. Feedwater and steam flowmeters are provided on each boiler. There is a coal scale in each burner line. The instrument records for each day provide the data of a boiler test for continuous check of the efficiency. A plant total steam flowmeter is in the main header.

Soot blowers are steam and have retractable elements in all hot passes. Rotary elements are used in the second and third passes, with a traveling unit in the air heater.

Individual, lined, steel stub stacks are used on each boiler.

Coal is handled by gravity and cross conveyor through track hopper, crusher, and magnetic pulley, to vertical bucket elevator which takes it to a flight conveyor for storage in six tanks, one for each pulverizer, having a capacity of 100 tons or 48 hours each. To reduce the labor of unloading frozen cars, a car thawing installation is provided.

Ashes are removed from flat furnace floors by steam jet. Ashes, soot, and flyash are conveyed from their respective hoppers by pneumatic conveyor to a storage tank equipped with wet unloader for railroad car or truck.

Feedwater treatment is the hot process in which calcium is precipitated as the phosphate, magnesium as the hydroxide. The heater is of the spray deaerator type and contains compartments for handling both makeup water and condensate.

Feedwater pumps are two centrifugal four-stage dual drive units each of full plant capacity.

Pressure reducing valves and desuperheaters are provided to bring turbine extraction steam and bypass steam to the proper conditions for the plant. A total temperature limitation of 400 F was set because of existing reciprocating engines.

Power in the boiler house is provided by a separate indoor power center located on the firing floor.

This equipment is being installed in a new steel frame building with reinforced concrete slab and built up roof, corrugated asbestos siding, steel sash, reinforced concrete, and grating floors, steel stairs and ladders. The building is functional and provides a space for each activity as well as places for possible future auxiliaries and storage of parts and supplies. An office is located centrally to overlook both the boiler house and the turbine room. It is soundproofed and has a laboratory sink for conducting water tests and servicing orsat analyzers, inclined draft gages, and other test equipment. A clock and a remote master flowmeter repeater are the only instruments in the office.

This installation was justified by both necessity and savings. We estimated total savings of $155,000 per year made up of:

Fuel savings based on 82 per cent of the new boilers, 60 per cent for the old and $400,000 per year previous coal consumption. This showed a theoretical fuel saving of $146,500 per year. We took 60 per cent of this for our savings prediction or $88,000.

The labor for the new plant is estimated to be reduced by 50 per cent, and even allowing for the average higher grade of the jobs this will save $36,500.

Maintenance costs and supplies are expected to be reduced by $30,500 per year.

The predicted total of $155,000 allows the investment to be paid off in less than eight years. We believe that we will actually do better than this.

ELECTRIC POWER

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▲ THE problem of supplying power to an industrial plant is one of many parts. One phase of that problem is the supplying of the steam required for plant operation. Another phase of the same problem is the supply of electricity for the many plant uses to meet the ever increasing demand.

When considering the supply of electricity to a plant the question "Shall we purchase power from the local public utility company or shall we generate it in our plant?" usually comes to the front and must be answered.

In making a study of the possible replacement of boilers in a plant this question must be given careful study as it is practical to generate steam at higher pressure and temperature than required for plant use and to economically generate a portion of the electricity required by the plant, in reducing the steam pressure and temperature to the values desired for general plant use.

Engineers have for years been familiar with the use of controlled extraction turbo-generators for this purpose and the results of their operation have proven that when such equipment is used the fuel required to produce a kwhr of electricity is much less than that required to generate in the usual manner with condensing turbo-generators.

The total heat of steam is composed of two components, the heat of the liquid and the heat of vaporization. This heat of vaporization serves no useful purpose when steam is used to generate electricity in the usual manner, by means of condensing turbines, but must be dissipated in the condenser cooling water. As the pressure of steam is increased the total heat of the steam does not keep pace with pressure increase but reaches a point where increased pressure results in no increase of the total heat. We can, however, increase the total heat per pound of steam by superheating the steam.

Figure 1 has been prepared to show the effect of pressure and superheat on the total heat of steam. In modern boilers this superheat can be added to the steam very efficiently.

As the heat of vaporization is lost in a condensing turbo-generator, it is evident that the efficiency of generation must be in direct relationship to the total heat in the steam at the turbine throttle. To show graphically the effect of increased heat of steam on the fuel required to produce a kwhr of electricity, Figure 2 has been prepared.

This figure has been developed by referring to a standard set of conditions, for the purpose of comparison, published information of several turbine manufacturers. From this it is seen that the higher the temperature and pressure of the steam at the throttle, the more efficient the generation, or to put it in other words, an increase of the total heat in the steam entering a turbine results in a corresponding decrease in the fuel required to produce a unit of electrical power.

When a plant has a need for an appreciable amount of steam for heating or other processing, it is possible to generate steam in efficient boilers at high pressure and temperature and in reducing that pressure and temperature to the values required for plant use, to generate electricity with a fuel expenditure of 5000 Btu per kwhr or less as compared with the most modern condensing turbo-generator fuel rates of approximately 10,000 Btu per kwhr.

To more thoroughly study the principles which control the fuel expenditure to generate electricity with a controlled extraction turbine, let us refer to a representative performance curve for such a unit. A curve of this type is shown in Figure 3. When generating a full load with the maximum quantity of steam being extracted at 150 psi, 510 F, the total flow to the throttle is 166,000 lb per hour. Of this amount only 6000 pounds per hour is passed through the low pressure section of the turbine to provide the necessary cooling medium to prevent overheating of the blading due to windage, the balance, 160,000 lb per hr being extracted at 150 lb, 510 F for use elsewhere in the plant. The fuel required to produce a kwhr of electricity in this case can be calculated by the following formula:

$$F = \frac{S_n(H_1-H_2)+S_c(H_1-H_3)}{0.82 \text{ kwhr}} =$$

$$\frac{(160{,}000\times 102)+(6000\times 1310)}{.82\times 5000} = 5775$$

$$\text{Eff} = \frac{3413}{5775} = 59.4 \text{ per cent overall}$$

S_n = lb steam per hr extracted
S_c = lb steam per hr to condenser
F = total fuel Btu per kwhr
H_1 = total heat per lb steam at throttle (1380 Btu per lb)
H_2 = total heat per lb steam at extraction point (1278 Btu per lb)
H_3 = total heat per lb condensate at condenser hotwell (70 Btu per lb at 2 in. Hg)
0.82 = efficiency of boiler

This formula gives the total fuel Btu per kwhr under a certain set of conditions, i.e., when carrying full load with maximum rated extraction, but it is readily seen that these conditions will not always exist, and in order to study what will happen under changed circumstances, we must go further in our calculations.

From the performance curve we find that the unit

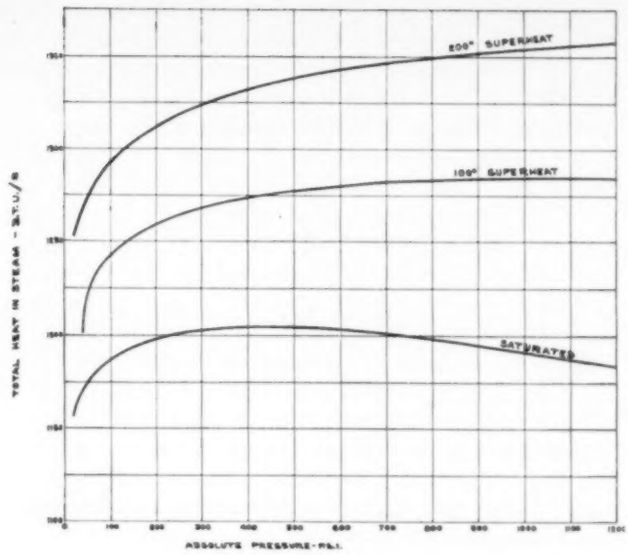


Figure 1 — The chart gives the total heat in steam at various pressures for unsaturated, 100 degrees superheat and 200 degrees superheat.

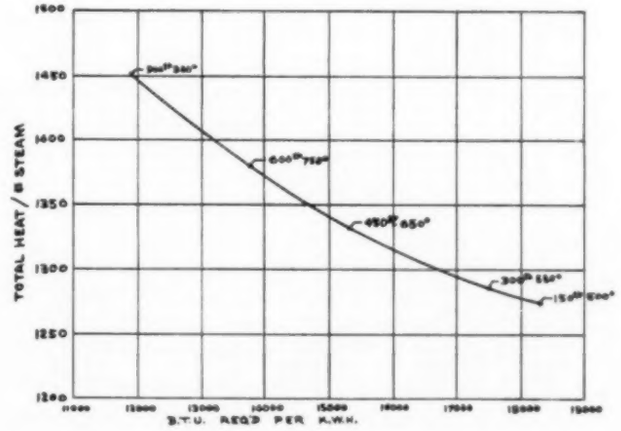
requires approximately 10.0 lb of steam per kwhr when operating with zero extraction. With only 6000 lb per hour passing through to the condenser, we are then generating only $\frac{6000}{10} = 600$ kw by condensing and the formula previously mentioned will give the fuel Btu per kwhr for this part of the cycle.

$$F_1 = \frac{S_c(H_1 - H_3)}{600 \times 0.82} = \frac{6000 \times 1310}{492} = 15{,}975$$

$$\text{Eff} = \frac{3{,}413}{15{,}975} = 21.4 \text{ per cent}$$

The balance of the load being generated by means of the steam being extracted and applying the same formula we find that the fuel expenditure in Btu per kwhr for the extraction portion is:

Figure 2 — The Btu per kwhr for various steam conditions are given by this chart.



$$F = \frac{S_n(H_1 - H_2)}{Kw \times 0.82} = \frac{160{,}000 \times 102}{4{,}400 \times 0.82} = 4523$$

$$\text{Eff} = \frac{3413}{4523} = 75.7 \text{ per cent}$$

With fuel costs in the area in which the plant is located approximately $0.30 per million Btu, the fuel cost per kwhr is readily determined:

$$\text{Condensing} \quad \frac{15{,}975}{1{,}000{,}000} \times 0.30 = \$0.00479 \text{ per kwhr}$$

$$\text{Non-condensing} \quad \frac{4{,}523}{1{,}000{,}000} \times 0.30 = \$0.00136 \text{ per kwhr}$$

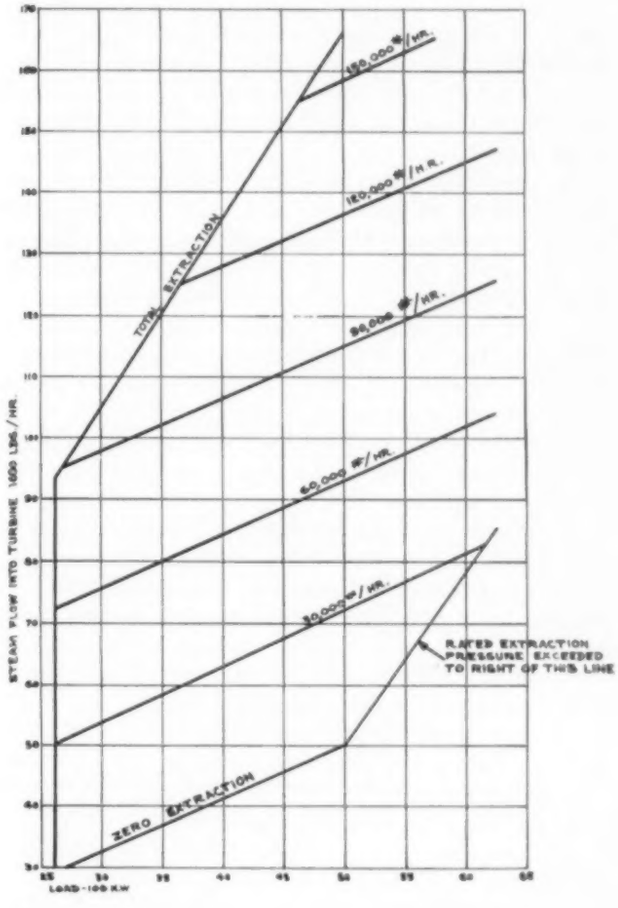


Figure 3 — Given here are the performance curves for a 5000 kw, condensing, single extraction turbine. Steam conditions at throttle are 600 psi gage 750 F. Extraction pressure is 150 psi gage, exhaust pressure is 2 in. hg absolute, cooling steam is 5700 lb per hr.

Calculating the cost of generation under both conditions of generation was only one step in the final solution of the problem that faced us in our plant. It was now necessary for us to ascertain what amount of power could be generated by the non-condensing part of the operation and what size unit would be best fitted to our needs.

Here we must return to a study of the steam require-

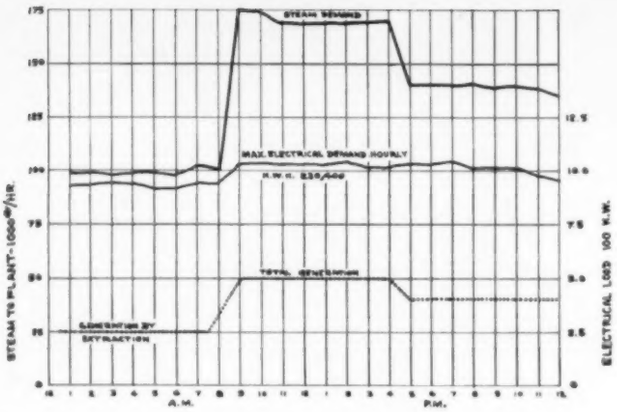


Figure 4 — Requirements for a typical day is given in this chart.

ments of the plant, and we will refer to Figure 4. To study the problem thoroughly, a representative day steam load and electrical load was plotted for both winter and summer, as well as operating and non-operating days.

This meant four complete sets of tabulations of steam requirements, electrical demand, electricity consumed, power to be generated, both condensing and non-condensing, and a check on heat balance of the system for each hour of the day in order to determine exactly what the amount of power generation would be. Then to make the study more complete this was repeated using each of four different sizes of turbo-generators, 3000, 4000, 5000 and 6000 kw.

Studies were also made on the basis of using a straight back pressure turbine and with a controlled extraction condensing turbine.

The results proved to us that this plant could best be served by the installation of a 5000 kw controlled extraction condensing turbine with throttle conditions of 600 psi, 750 F total temperature extraction at 150 psi. With this unit it was found that we could generate 30 per cent of the total electrical power, non-condensing, at a very low cost per kwhr for fuel as shown above. By the addition of a 3000 sq ft surface condenser, the power generated could be raised to approximately 50 per cent of the total requirements and the operation of the plant would be greatly simplified as the power generated would not be entirely dependent on the plant steam demands which are of necessity subject to variations and any variations could be smoothed out by allowing a greater or lesser amount of steam to pass through the low pressure end of the turbine to the condenser.

This would allow the generator to carry a uniform load and greatly increase the total generation. It is to be understood that this portion of the power to be generated during the condensing cycle is at a greater cost per kwhr than when non-condensing as we have previously shown, but it will still be well below the cost of purchased power.

The power for this plant has been purchased from the utility company at their established wholesale power and lighting rate. I will not go into all the details of that rate except to say that it is composed of (1) a demand charge that is determined by the maximum daily demand for power; (2) an energy charge for the actual kwhr consumed monthly; (3) a fuel adjustment charge based on their fuel cost for the previous three months. A summary of the application of that rate for an average month is shown in Table I (the cost of purchased power during the past year averaged approximately $0.0087 per kwhr). It should be noted here that during the past year the plant had an average monthly consumption of 5,250,000 kwhr with a maximum demand of 11,000 kw. As the plant normally operates five days each week on a three-shift basis, the load on non-operating days being only 1000 kw, it is readily seen that the load factor during the working days is over 90 per cent and when the entire month is taken the load factor is nearly 64 per cent.

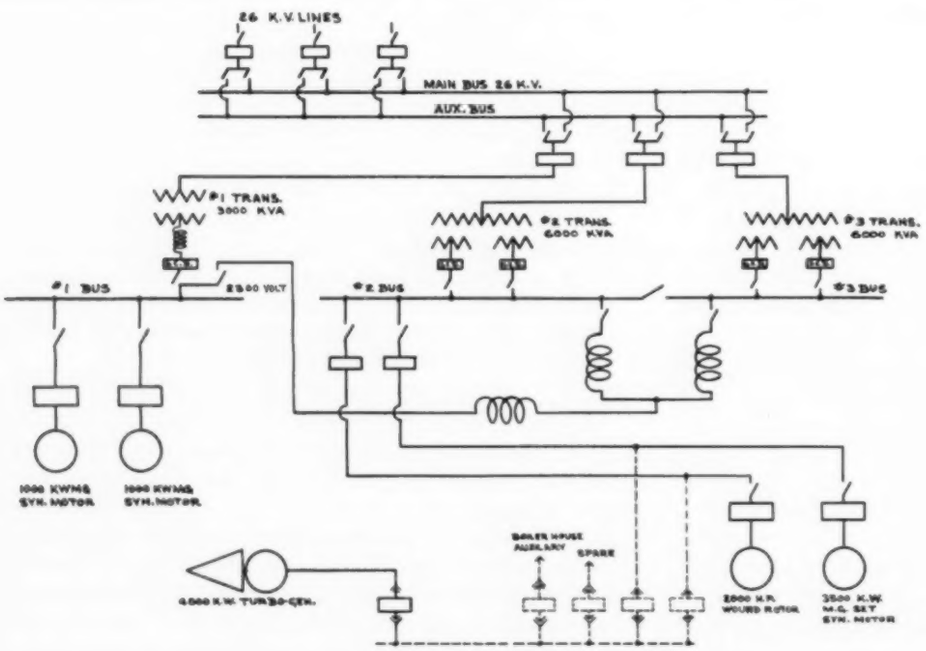


Figure 5 — Line diagram of the John A. Roebling's Sons Company plant at Roebling, New Jersey

TABLE I

Demand or kw charge	
11,000 kw @ $1.10 per kw+$410.00	$12,510.00
Energy or kwhr charge	
5,000,000 kwhr @ $0.005+$2200.00	27,200.00
Total	$39,710.00
Less discount 10 per cent not exceeding $3000.00 per month	3,000.00
	36,716.00
Fuel adjustment charge @ $0.00123 per kwhr	6,150.00
Net cost per month	$42,860.00
Average cost per kwhr	$0.008572

The utility company also has a rate called the auxiliary or breakdown rate which is used when a customer generates all or part of his power requirements. This rate like the wholesale power and lighting rate includes charges for maximum daily demand, energy in kwhr consumed, fuel adjustment charge and in addition a contract capacity charge.

This charge is in effect a charge made to cover the expense of having sufficient capacity available to carry the contracted load when and if needed. A summary of the application of that rate is shown in Table II.

TABLE II

Contract capacity charge 11,000 kw	
$0.60 per kw plus $135.00	$ 6,735.00
Demand charge 11,000 kw	
$0.60 per kw plus $135.00	6,735.00
Energy charge 5,000,000 kwhr	
$0.005 per kw plus $2,215.00	27,215.00
Total	$40,685.00
Less discount 10 per cent not exceeding $3,000.00 per month	3,000.00
	37,685.00
Fuel adjustment charge @ $0.00123 per kw	6,150.00
Net cost per month	$43,835.00
Average cost per kwhr	$0.008767

Please note that the contract capacity charge is placed at the same value (11,000 kw) as the demand charge in the figure that outlined the wholesale power and lighting rate.

When the power supplied is partly from the public utility and the balance generated in our plant, a typical monthly bill may be approximated by estimating the power generation per month under both condensing and non-condensing operation and making the changes in the summary shown in Table II to arrive at a net cost of power per month.

Before further discussing the effect of rate applications, it is necessary to ascertain the average monthly generation, both condensing and non-condensing.

From the curve of Figure 4 it can be seen that during a normal day the plant steam requirements are sufficient to enable the generation of over 92,000 kwhr per day, which when expanded to a monthly basis becomes in excess of 1,750,000 kwhr per month by extraction and at the same time approximately 1,000,000 kwhr per month may be generated by condensing.

While it has been shown that the fuel cost per kwhr non-condensing generation is $0.00136, that figure has been increased to $0.0017 to cover the additional boiler and auxiliary maintenance, and the cost per kwhr condensing has been increased from $0.00479 to $0.005 for the same reasons.

In summarizing the monthly cost of power for the plant, we now have an average monthly cost given in Table III, even when contract capacity is maintained at the present full demand level.

TABLE III

Contract capacity charge		
11,000 kw @ $0.60 per kw+$135.00		$ 6,735.00
Demand charge		
7,000 kw @ $0.60 per kw+$135.00		4,335.00
Energy charge		
2,500,000 kwhr @ $0.005 per kwhr+$2,215.00		14,715.00
		$ 25,785.00
Less 10 per cent discount (primary service)		2,578.50
		23,206.50
Fuel adjustment charge		
2,500,000 kwhr @ $0.00123		3,075.00
Total purchased power		26,281.50
Generation		
1,750,000 kwhr @ $0.0017 (fuel cost)	$2,975.00	
1,000,000 kwhr @ $0.005 (fuel cost)	5,000.00	
		7,975.00
Total per month		34,256.50
Average cost per kwhr		$0.006525
Cost per month (all purchased)		$ 45,675.00
5,250,000 kwhr @ $0.0087 per kwhr		
Differential per month		$ 11,418.50
Differential per year		$137,022.00

From this total differential we subtract an estimated $30,000 per year to cover the cost of operating labor and maintenance of the generating equipment, and leave a net differential of $107,000 per year to cover the fixed charges on the project. This is equal to approximately 25 per cent of installed cost of equipment.

The equipment being installed will consist of a 5000 kw 2400/4160-volt, 3-phase, 60-cycle generator direct connected to an extraction condensing turbine. The generator and exciter will be cooled by air which in turn will be recirculated through a water to air heat exchanger.

The switchgear will be of the metal enclosed type with air circuit breakers having an interrupting capacity of 250,000 kva at 4160 volts.

The power supply for the electrically driven boiler house auxiliaries will consist of two 500/625-kva, 2400/440-volt unit substations with air cooled transformer and necessary switchgear located on the operating floor of the boiler house. These units will normally be operated in parallel, but provision has been made to isolate either one in the event of transformer fault. To insure greater reliability of operation each of these transformers will be connected to a separate line.

In addition to these unit substations, the plant will have two 200-hp 2400-volt synchronous motors direct connected to air compressors and one 2400-volt, 400-hp motor direct connected to the boiler feed pump previously mentioned.

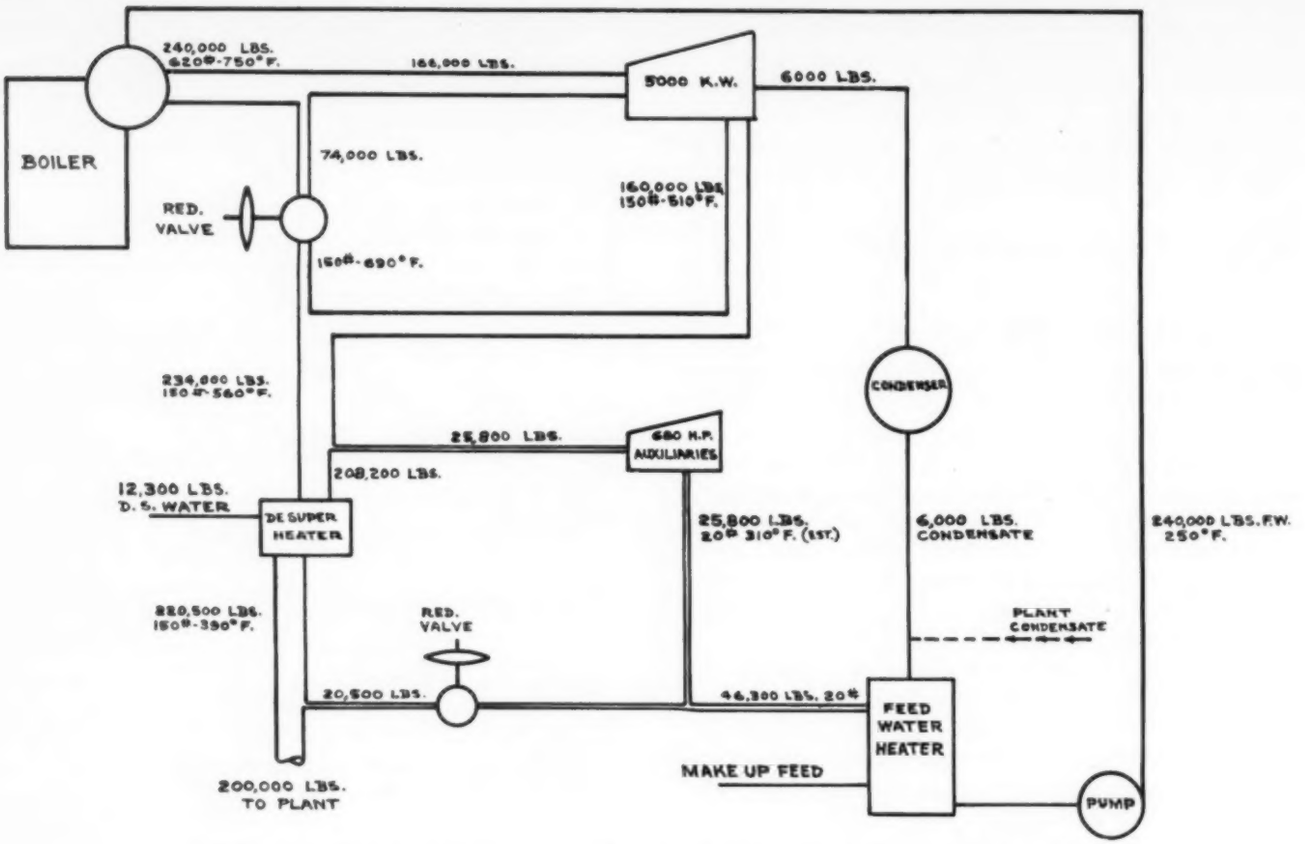


Figure 6 — The steam flow balance sheet is given for maximum steam demand.

The new station will be connected to the present 2400 volt secondary distribution system in the manner shown in Figure 5.

The turbo-generator is expected to carry approximately full load during the operating days of the plant, operating in parallel with the present power supply, with routine maintenance being carried out on the non-operating days.

The steam flow balance of the plant under maximum steam demand is as shown in Figure 6. Under this condition it will be necessary to pass 74,000 lb per hr through the pressure regulating valve to be added to the 160,000 lb per hr extracted from the turbine to supply the steam required for plant operation.

This steam will have a total temperature of 690 F and will be combined with that extracted from the turbine which will be at a temperature of 510 F. As the plant steam temperature is limited to 400 F, this steam, except for the 25,800 lb per hr required for boiler house auxiliary drives, will be passed through a desuperheater where the addition of water necessary to cool this quantity of steam to the desired temperature of 390 F will increase the steam flow by 12,300 lb per hr.

Under these conditions of maximum flow the auxiliary turbine drives will not be able to supply all the steam needed for feedwater heating, so the balance (20,500 lb per hr) will be supplied through a reducing valve from the 150 psi 390 F line.

This paper is not being presented to advise any industrial plant to enter into competition with the local utility company in the generation of power, as the utility companies throughout the country have demonstrated by their reliable service and the continued reduction in power costs, that they are an important part of our country's industrial machine.

It is important, however, to point out that where conditions, such as we have discussed, warrant the replacing of present boiler equipment, a complete engineering survey should be made of the plant power requirements and no decision on the replacement made until the results of that survey have been carefully studied, as no simple formula has as yet been developed that will enable the engineer to solve the problem of whether to generate power in the plant or to purchase it from the utility company.

If the results of that survey indicate that a substantial saving in power cost can be made by the generation of a portion of the power required, then a satisfactory working agreement must be made with the utility company.

DISCUSSION

PRESENTED BY

T. A. BESSENT, Mechanical Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

L. F. COFFIN, Superintendent, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland

H. S. HALL, Fuel Engineer, Lukens Steel Company, Coatesville, Pennsylvania

HOWARD G. KITT, Power Engineer, United Engineers and Constructors, Inc., Philadelphia, Pennsylvania

A. J. FISHER, Assistant Chief Engineer of Construction, Bethlehem Steel Company, Bethlehem, Pennsylvania

F. A. BAKER, Assistant to Chief Engineer, Bethlehem Steel Company, Bethlehem, Pennsylvania

STEWART MILLER, President, Robinson Company, Inc., Philadelphia, Pennsylvania

J. M. SPENCER, Steam Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

FRED C. SCHOEN, Maintenance Engineer, Alan Wood Steel Company, Conshohocken, Pennsylvania

H. D. FORREST, Power Engineer, United Engineers and Constructors, Inc., Philadelphia, Pennsylvania

T. A. Bessent: I would like to ask, if in the event it is necessary to take the turbine off for repairs of some other reason whether the reducing valve which you spoke of is of sufficient capacity to take care of the total load to supply the plant steam?

L. F. Coffin: I would like to ask what percentage of availability you have used for your boilers and turbine? Is your turbine inspection period to be annual or every two years? There can be no doubt but that a plant having considerable use for process steam, is almost forced, from the economic point of view, to install their own power plant, utilizing the steam from extraction or topping turbines.

H. S. Hall: I would like to ask, why did you consider a condensing turbine rather than a pure topping turbine, inasmuch as you only put in 6000 lb of steam per hour for cooling of the turbine?

We made a study some time back, and our figures came out to all topping turbines. I would like to ask also, why you used 650 psi rather than 900 psi boiler pressure?

Howard G. Kitt: You stated that you were putting dual drive on your auxiliaries which would use steam at boiler presure, and exhausting some of the steam from the main turbine to a condenser. Why did you not take an additional lower extraction point of your main turbine for heating steam and use all-electric drive? I have always felt that it was cheaper to generate electric power in a large turbine and use it for motor drive than it would be to use the same steam in a small auxiliary turbine drive. Perhaps an additional extraction point was not available.

A. J. Fisher: I can appreciate the amount of labor the author went through calculating their problem. Having gone through such a problem several times at the Sparrows Point plant, I can appreciate it all the more. It puts me in mind of polishing a rough stone—you start in with a lot of jagged-edge work on one facet and then another, and so on, and then you look at the whole stone to see if it makes sense. If it does not sparkle when you get finished, the boss says "Start all over again."

First, I have two questions to ask the authors: You chose 650 psi or 670 degrees, why did you not take 850 psi, 900 degree, or 1250 psi, or 950 degrees?

The second question has to do with topping versus extraction turbines. At Sparrows Point we worked up a problem involving some 160,000 kw total load, and in working that through found the greatest percentage return on the topping turbine; showing a lesser degree of return for the extraction turbine. That problem was dealing with 30,000 kw condensing units with a topping unit of 20,000 kw.

However, I think, in the size that the authors are speaking of in the lower capacities and taking their plant load into consideration, the extraction turbine would probably be the better.

F. A. Baker: I believe what you might call "packaged units" are being manufactured that is, the turbine, condenser, heaters and lubricating system all mounted on a unit fabricated steel substructure, and I was curious to know if you were using one of these? If not, why?

Stewart Miller: In this particular plant there is a new building that houses equipment, and as many of us here know, quite frequently when new equipment of this sort is bought and selected, it has to be housed in an existing building, and has to be so selected and designed that it will fit into the building, even though the building may be 35 years old. Now, I would be interested in hearing how management was convinced it was wise to build a new building to house this equipment.

J. M. Spencer: Mr. Yard mentioned rather incidentally that they had installed car-thawing equipment. I would like to inquire as to the details of that equipment, and any performance data Mr. Yard may have available, such as the amount of time required to empty cars, and so on?

Fred C. Schoen: There are a couple of points I cannot quite agree with. For one thing, I believe the paper mentioned that you charged the electric power when running the electric turbine, at fuel cost only of the steam. I think that is well justified if you have a good, large steam generating plant with excess equipment and are considering putting in a turbine, but I do not quite see the justification on only bare fuel cost when you are putting in both boiler and generators. It would appear to me your plant accountants may have something to say about it when you figure your cost of operation. I think you are going to find you have the same approximate costs as if purchasing power. I would like to have that cleared up.

What is the anticipated loading factor with the new unit, on the seven day basis? We were given about a 90 per cent load factor on the five day basis, and I think 64 without equipment. I was just wondering what he was anticipating with the new equipment?

H. D. Forrest: In reply to the question as to why higher pressure and temperatures were not employed I would like to point out that as the design pressure and temperature of the station is raised the percentage increase in investment for a given increase in steam conditions goes up more rapidly for a small plant than for a large one, while the increase in efficiency is not as great for the small plant as for the larger one. Consequently the point at which incremental investment cost balances operating savings is reached at lower steam conditions in the small plant. For plants of the size discussed in the paper a temperature of 750 F is practical since steam temperatures in excess of 750 require the

use of special steels at a considerable increase in cost.

The authors compared investment and operating costs of low pressure steam generation with high pressure steam generation coupled with power generation, but it was not clear to me whether they had charged power generation with the extra investment and operating costs of the hot phosphate water treating system as compared with the costs of some simpler treatment which might have been used with low pressure steam generation.

E. M. Yard: Our winter operating load is about 100,000 lb on the first shift, and about 200,000 lb on the second shift, and about 150,000 lb on the third shift. The summer operating load is about 30,000 lb first shift, which is essentially idle, and 112,000 lb on the second shift, and somewhere around 80,000 lb on the third shift, that will give you a better picture of what we are talking about, when we speak about loads.

Now, in answer to the question as to whether or not the reducing valves can pass the steam needed for the plant when the turbine is out of service, we are installing two reducing valves and their capacity is adequate to supply the plant when the turbine is out of service.

In answer to the question of what per cent availability do we expect on the boilers, we expect 90 per cent or better. Due to the variations of the load, the fact that on week ends, the loads are normally quite a bit lower, and the fact that in the summer the load is as low as 112,000 to 30,000 lb per hour we feel we will have plenty of time for maintenance on these three units.

In answer to the questions as to why we chose the pressure and temperature that we did: these quantities of steam at that pressure will generate as much power as is economically justified. Any further increases in pressure increases the cost of the plant without comparable greater returns.

In answer to the question as to why we did not derive all of our feedwater heating-steam from an extraction point on the turbine, we studied that, and found that with the variable loads and pressures at that extraction point, the whole thing did not work out, and we could get as good economy by using a certain amount of auxiliary drive, and taking the rest of the steam out of the turbine, at the 150 psi point.

We decided on a new building because after thoroughly studying the old building, it just did not fit. The large amount of alteration necessary would have cost just as much as a new building. So, we put up a new building.

We do not have any actual operations cost on the car thawing installation. As for the details of that, it consists of fire brick lined pits beneath the track, which are heated by oil burners. The radiation from the hot brick is thrown up into the car melting any ice, and if you leave a car over it long enough the water goes up as steam and melts the ice at the top. We understand that about thirty minutes is normally the time to thaw a car, and as far as the fuel cost is concerned, it is much less than beating the coal out of the car.

In answer to the question as to whether the cost of feedwater treatment was considered, and the cost of feedwater for a year, etc., the cost of feedwater a year is so low with Delaware River water, that whether or not we had high pressure boilers, we ought to treat it. There is no excuse for not giving it some kind of treatment because Delaware River water is so soft that this cost is negligible by comparison with other operating costs.

W. E. Zelley: Mr. Schoen asked why we chose to use only the fuel cost in calculating the cost of generation. The steam generating equipment is already in the station. Our plant steam demands make it necessary to have boiler equipment of sufficient capacity that no additional boiler equipment was required, and the steam flow curve Mr. Yard has shown shows very clearly that it would be rather bothersome at any rate, to use two or three units, 16 hours of the day, and drop them off entirely in the night shift, or cut them down to one or two, taking one off the line. The amount of labor involved in boiler operation is the same. There is no additional labor involved in the generation other than has been noted, which is the labor involved in the actual turbo-generator operation, so that the actual cost of power generated by this unit is purely a fuel cost item. Of course, that is a matter that some other people might want to argue, but that is the way we see it.

Mr. Coffin asked about turbine and boiler availability. I believe Mr. Yard has already answered the question as to boiler availability. Turbine availability is, with modern equipment, very high and normal routine inspections are always required, and usually there is sufficient down time in the plant to take care of that—vacation periods, and shutdown, holiday periods, and things of that sort.

The question was asked why the condenser was used if normally only 6,000 lb of steam per hr went to the condenser. The condenser was added to simplify the control and to take care of any changes that might crop up in our plant operation. If any radical change took place in our steam demands, additional steam could be passed through the condenser and maintain a somewhat decreased saving, but still a substantial saving in the operation.

The question was asked by Mr. Fisher as to why extraction, rather than a topping turbine was used? We made a complete study and felt that the use of a non-condensing turbine would give considerable difficulty in carrying uniform loads with the variations that exist. We would have quite a wide variation in load on the generator as well as on the utility.

Mr. Baker asked if the unit is a standard packaged unit turbine or turbo-generator unit. It is not of the type usually called a packaged unit, but it is of a standard design.

Mr. Schoen has asked what our anticipated load factor would be when the generator is in operation. It will not vary greatly from our present day. We expect to be carrying fairly constant loads, as the condenser will assist in carrying uniform loads.

Mr. Forrest asked about the consideration given to the added cost of boilers and boiler feedwater, water treating equipment due to the higher pressure required to generate. I believe Mr. Yard has fully covered that. We did, however, give consideration to the increase in costs before actually evaluating the process.

Submerged Melt Welding IN STEEL MILLS

. . . . submerged melt welding can be used to apply heavier beads in one pass at faster rates than the manual arc method . . . .

By E. D. MORRIS, Manager
Unionmelt Process Service
The Linde Air Products Company
Chicago, Illinois

▲ SINCE the sumberged-melt welding process was first introduced it has been applied to a wide variety of operations in the metal working industries. At first, it was conceived as an ideal tool for welding heavy material in the downhand position. As a result of continual development work it is now applied to material as thin as 18-gage sheet, which is welded at the rate of 200 in. per minute. The applications vary all the way from thin-gage to almost anv thickness of material. Plate 1½ in. thick can be welded in a single pass at a speed of 7 or 8 in. per minute and multipass welds 10 in. thick have been used in important fabrication.

The use of submerged-melt welding in steel mills is of two general types: the fabrication of equipment of various kinds, and the reclaiming of worn surfaces through build-up operations. In past years, most of the various kinds of operating equipment that are required in steel mills were purchased from outside sources. Several mills are now finding it advantageous to make some of the equipment themselves instead of purchasing it. A study has been made of the welding departments of several mills to determine the actual savings through the use of the submerged-melt welding process. The comparative costs were obtained from actual production installations and they will be given in the following discussion of applications.

MAKING EQUIPMENT

The fabrication of coil-annealing covers is one example of the use of this process in steel mills. These covers are made of ½ in. plate as shown in Figure 1. One longitudinal and two girth welds are made. The welds are completed in a single pass at a speed of 20 in. per minute. Originally, one cover was fabricated in 8 hours by one man. An operator and a helper can fabricate eight covers by the submerged-melt welding process in the same time. The estimated savings of labor costs and material on each cover was about $15. This mill required 600 covers per year which would account for an annual saving of over $9,000 on this one item.

Coil-annealing bottoms are also fabricated by steel mills. By changing the design slightly, it was possible to make them by the submerged-melt welding process which decreased the cost from $225 each to $125 each. The direct saving through the use of automatic welding over hand-welding was $45 per unit. Three hundred bottoms are required yearly in this mill, showing an annual saving of $13,500.

In one of the plants studied, two types of water-cooled rails are used in connection with the soaking pits. The single type of rail required 180 ft of welding. The double type of rail required 360 ft of welding. No cost data were available on this application. The parts can easily be fabricated by the submerged-melt welding

Figure 1 — The annealing coil cover shown was fabricated by welding ½ in. plate.

Presented before AISE Chicago District Section Meeting, March 2, 1948

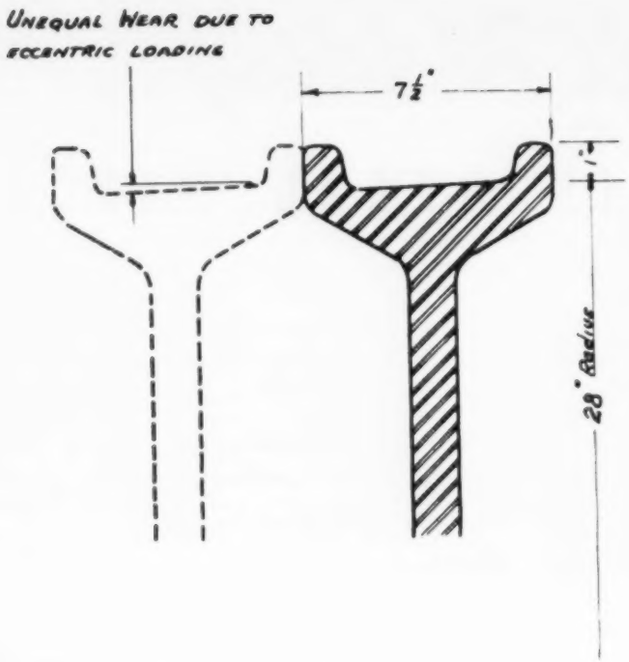


Figure 2 — Crane wheels are mounted in pairs for rebuilding of faces and flanges. The wheels are paired to act as melt retainers and then reversed. The wheels shown in the sketch are welded with 600 amp, d-c, reverse polarity, at a rate of 18 to 20 in. per minute. Final hardness runs 280-300 Bhn and the wheels, which are cast steel, are machinable as welded.

process and the savings would depend on the speed of automatic welding over hand welding.

At another mill, lengths of skid pipe are being turned out at the rate of 14 per day. Each section is 15 ft long and requires 30 ft of welding. Three skid-pipe units per day were produced by previous methods. In addition to the savings in time, there was a saving of $2 per unit when designed for automatic welding.

Numerous other pieces of equipment in addition to those already described are being fabricated. These include:

Ingot boxes (for hot transfer of ingots).
Galvanizing pots.
Open hearth doors and frames.
Scrap boxes.
Tanks and containers of all kinds.
Pipe.

BUILDING UP WORN SURFACES

The building up of worn surfaces is a rather new but rapidly increasing application of the process in steel mill maintenance. The following paragraphs will discuss several of the items that have been reclaimed by this method. Several welding rods are available which when used with the proper type of granulated composition, give the desired hardness and type of surface required. It is possible to obtain a hardness range of 150 to 325 Bhn in the weld metal deposit, using a relatively inexpensive rod. The deposit thus obtained can be further

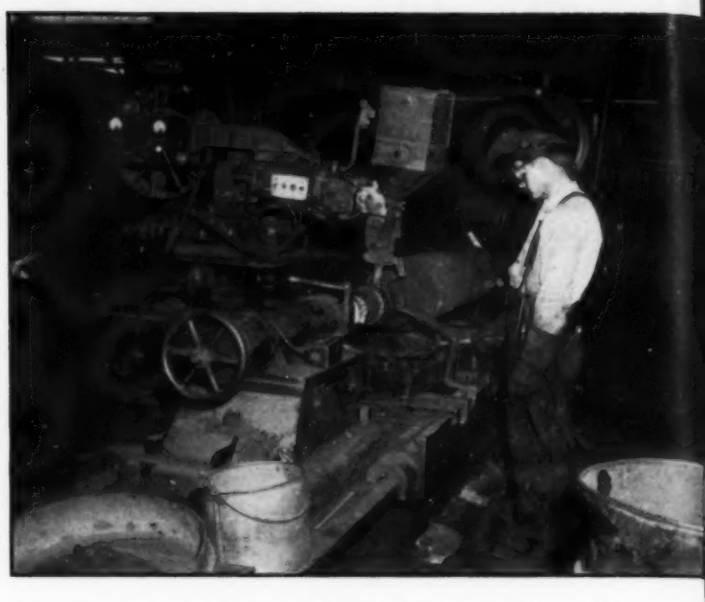


Figure 3 — The neck of a table roll is being rebuilt by the submerged melt process.

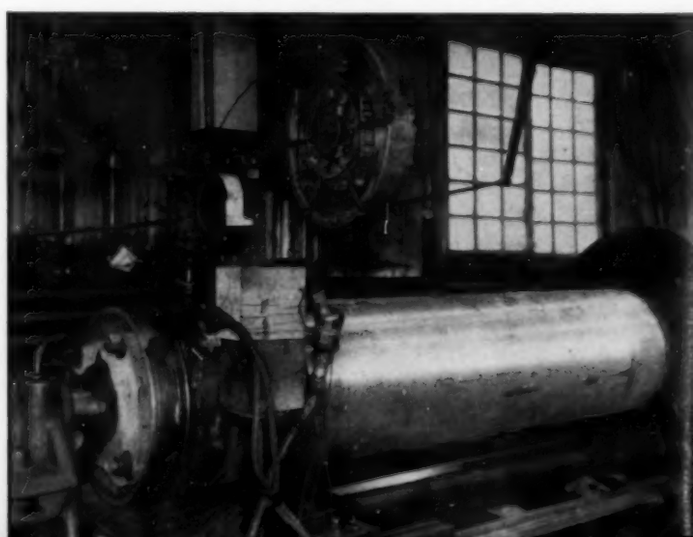
hardened by applying the flame-hardening process. By the use of special chromium alloy rods, a hardness of 575 Bhn is obtainable in the "as-welded" condition.

Cast steel crane wheels (as shown in Figure 2) are being reclaimed in numerous mills. Not only the bearing surface but also the flanges are being rebuilt. SAE No. 6150 rod is used for making the built-up deposit. A typical 24-in. diameter double-flanged wheel which costs $75 new, was reclaimed for $25 by the submerged-melt welding process. This figure includes the necessary machining cost. No trouble has been experienced with flat spots caused by the swinging of heavy loads when the crane is stationary. A similar operation is the reclaiming of slab transfer wheels. Blooming mill spindles are also resurfaced in the same manner.

Cast steel edging rolls which originally cost $144 new are being reclaimed for a total cost of $75. In addition to the saving in first cost, these rolls last about 2½ times as long as the new rolls.

One of the major applications in steel mills is the reclaiming of rolls and roll necks. Figure 3 shows how the submerged melt process is used to build up the neck of a table roll. Ordinarily, SAE 6150 rod is used; how-

Figure 4 — Submerged melt welding is being used to reclaim a hydraulic press plunger in the photograph.



ever, in some mills this neck becomes the bearing race and requires a hard surface. For such service a 12-14 per cent chrome rod is used.

The rolls themselves are reclaimed in the same manner, from two to four layers are deposited to provide the required amount of material. No machining is necessary on this type of roll.

A worn and pitted hydraulic press plunger was reclaimed by this process, as shown in Figure 4. The 9 ft 2 in. long plunger was machined down to ½ in. undersize to remove defects and to get clean metal. Two passes were made depositing sufficient metal so that the piece could be finished to 24⅛ in. diameter. Metal can

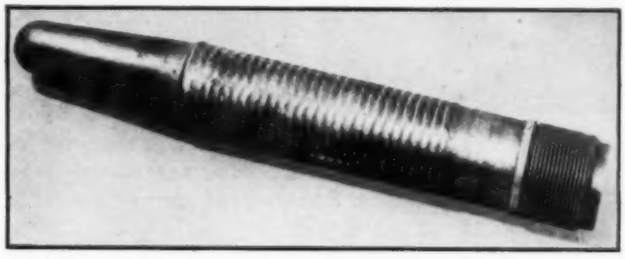


Figure 5 — The smooth surface of the deposit is shown in the photograph where a 3 in. shell piercing tube has been rebuilt.

be successfully deposited in this way on pieces as small as 2 in. in diameter. This limit results from the fact that the molten puddle must be balanced on the top of the round section. However, the largest diameter that can be rebuilt is limited only by the facilities for turning the piece. Figure 5 shows the smooth surface of the deposit that can be applied at a high rate of speed and as a continuous operation on small sized material. The section is 3 in. in diameter.

The installation for reclaiming a back-up roll, shown in Figure 6 uses the method just described with the addition of facilities for preheating the roll. The spalled areas of the roll were first machined out and then a cut was taken from the entire roll to produce a good sound metal base for welding. The roll was examined, using the supersonic detection method to be sure there were no cracks, and was then placed in the furnace which was built around the turning mechanism. The roll was

Figure 6 — The installation for rebuilding a back-up roll requires preheating facilities.

then preheated to the desired temperature, approximately 700 F, being brought up to this temperature at the rate of 10 to 15 degrees per hour as the roll turned. The roll was held at this temperature during the welding operation. The welding was started by using a welding rod having about 2 per cent Mn and some Mo, until a layer of metal approximately ½ in. thick had been added. The roll was then finished using SAE Type 6150 welding rod. A welding current of 1,000 to 1,100 amperes was used with direct current, straight polarity. Each layer was welded in two steps. The welding was started from one end and carried to the center. The second half of the layer was then started at the other end and carried in to meet the first half. The laps in the middle of each layer were staggered. Approximately 1,000 lb of rod was deposited in 24 hours. The time to complete the operation would naturally depend on the wear of the roll and the amount of material deposited to bring it up to size. The back-up roll shown in the illustration required 14,000 lb of welding rod to bring the diameter from 48½ to 54 in. After welding, the temperature of the roll was

Figure 7 — Appearance of back-up rolls after welding has been completed and before finish machining.

raised to 1050 F and held at that temperature for 24 hours. The temperature was then dropped 10 to 15 degrees per hour until 400 F was reached. When cool, the roll was removed from the furnace for machining. Figure 7 shows a close-up of the roll after welding had been completed.

The cost of reclaiming a 54 in. diameter roll, 90 in. long, is from $5,000 to $8,000 depending on the amount of build-up required. It is expected that, by using improved welding and jigging techniques, the cost can be reduced from 20 to 30 per cent. In the rebuilding operation, using the submerged-melt welding process, the diameter of the sections being welded limits the current that can be used. Consequently, welding rod will be deposited at various rates depending on the size of the section welded. The rate of depositing metal will vary from 10 to 75 lb per hour, while 4 to 6 lb per hour is deposited by hand. For estimating purposes, the direct cost of labor and materials to deposit a cubic inch of metal by submerged-melt welding is approximately

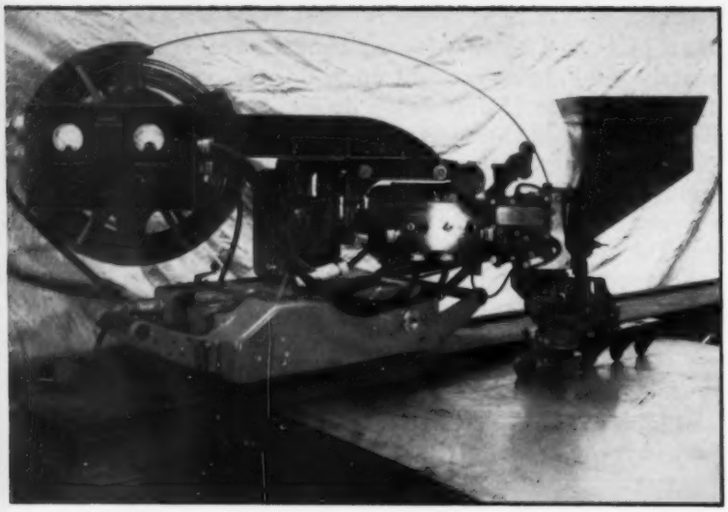


Figure 8 — The welding head shown in the photograph is the one that is most widely used for build-up and fabrication.

Figure 10 — The machine shown has been designed for flexibility and also to enable the operator to reach places where ordinary equipment cannot reach.

$0.09. To deposit the same amount of metal by hand will cost approximately $0.15 at the lowest estimate. In average applications, the reclaiming cost is approximately 35 per cent of the original cost.

The large savings given in these examples are readily explained if manual welding speeds are compared with submerged-melt welding speeds. Here are a few examples using AWS E-6010 reverse polarity electrodes in order to come close to the physical test results of submerged-melt welding standards:

Butt welds were made in ¼ in. plate with no edge preparation and a 1/16 in. spacing. Welding was completed by hand, using two passes, at a total speed of 1.13 in. per minute as against 32 in. per minute and a single pass operation with submerged-melt welding.

With welds made on ½ in. plate using a 60 degree bevel edge preparation and a back-up strip for complete penetration with a 3/16 in. space at the bottom, a single-pass hand weld can be made at a rate of 0.497 in. per minute against 16 in. per minute with submerged-melt welding.

Welds were made on 1 in. plate with a 60 degree bevel down to a feather edge. Three hand passes were needed to make the weld at a speed of 0.196 in. per minute as compared with 11 in. per minute by the submerged-melt method. On this type of welding, a backup of either steel, copper or granular composition was used.

Welds were made in 1½ in. plate, prepared with a double "V" to a feather edge, using a ⅛ in. space. The hand welding speed was 0.146 in. per minute. Multi-pass welding was required which meant that chipping of slag and wire brushing had to be done between each pass. Welding by the submerged-melt process was done in two passes at 9 or 10 in. per minute, and no chipping and cleaning of the weld was necessary.

A brief description of the apparatus used in both fabrication and build-up applications of the submerged-melt welding process is included for those who may not be familiar with the process. The welding head shown in Figure 8 is electronically controlled and has a maximum current capacity of 2,000 amperes. It is the most widely used head for build-up and fabrication. With this current range it can be used to weld material from 18 gage to 1½ in. plate in a single pass. Almost any thickness can be welded by a suitable number of passes.

Two other machines deserve mention. One is a machine which consists of a type U head mounted on a machine originally designed to carry an oxy-acetylene torch for shape-cutting. See Figure 9. This enables welds to be made on any desired outline. The work capacity is the same as for the usual mounting of the head.

The most recent of the machines is the automatic flexible welder shown in Figure 10. The main feature of this machine is the fact that the welding rod and welding composition are automatically fed out of the nozzle at the end of a 20 ft flexible hose. The nozzle piece can be held in the operator's hand and quickly moved from one work location to another. While it can be used for construction and repair, its chief use is considered to be in depositing metal for rough build-up of pads, bosses, reinforcing areas and for repairing defects. Its flexibility suits it for welding in places that ordinary mechanized equipment could not reach, or where a number of short welds are to be made and the time required to set up the fully automatic apparatus would not be worthwhile.

Figure 9 — The welding machine shown enables welds to be made on any desired shape.

DYNAMIC BRAKING MAGNETIC HOIST CONTROLLER

. . . . the controller described is fundamentally the same as the standard magnetic controller, but does have some rather ingenious variations from the conventional design . . . .

By K. S. KUKA
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Jamshedpur, India

▲ THE best developed crane hoist control system commonly used is one in which the hoist motor is built as a direct current series motor. The control system is so designed that the motor works as a simple series motor during hoisting; whereas while lowering, the series field and the armature are connected in parallel and the motor works as shunt motor to provide dynamic braking torque for regenerative lowering. In such a system, it is the lowering cycle of the operation that requires greater attention and proper care. A well-designed controller should therefore have the following fundamental characteristic features:

1. The same manipulation of the master switch to any position in the lowering direction should cause the motor to develop either motoring torque to lower an empty hook, or a dynamic braking torque to balance an overhauling load to permit smooth lowering as the requirements at the moment demand.
2. The maximum lowering speed with empty hook should be at least as high as the full load lowering speed, limited to about 200 per cent of the rated full load hoisting speed.
3. The control should be such that with the provision for maximum lowering speed, the motor torque capacity available in the lowering direction is ample so as to handle with complete stability maximum loads which can be lifted by the crane.
4. A safe and reasonably smooth retardation and stop must automatically occur in the event of power failure or other emergency; the mechanical holding brake should be so controlled that in regular service it is not required to supply the whole energy required for retardation.
5. The electric equipment must be self-protective against abuse, either of itself or of the mechanical equipment, under conditions of rapid and unrestrained movements of the master switch handle; as also under fault conditions when dynamic braking action fails, causing sudden and dangerous overspeeding of the load.

Standard controllers incorporate the majority of the above fundamental characteristics, but never all of them in a single system, as that introduces complications in the control wiring and demands additional equipment.

It cannot be overstressed that one of the most important features of an overhead crane controller working under severe conditions that generally prevail, especially in steel works, is the simplicity of the control itself.

The object of this paper is to propose a crane hoist controller, which incorporates only standard equipment, maintains the general simplicity of control and introduces all safety features enumerated above.

Figure 1 gives the connection diagram both for the main power circuit and the control circuit. Figure 2 gives the nomenclature, sequence of operation and the control resistance steps expressed in per unit values. The fundamental method of control and the sequence of operation are the same as in any standard controller, except for the arrangement of the main power circuit and the distribution of control relays.

The fundamental features of the control system will now be discussed with reference to each of the main characteristic features specified above.

1. MAIN POWER CIRCUIT

The main power circuit is almost the same as in a standard controller, both for hoisting and lowering cycles, the direction of rotation being changed by the field reversal method.

The changeover from motoring to dynamic braking action is automatic depending on the hook load.

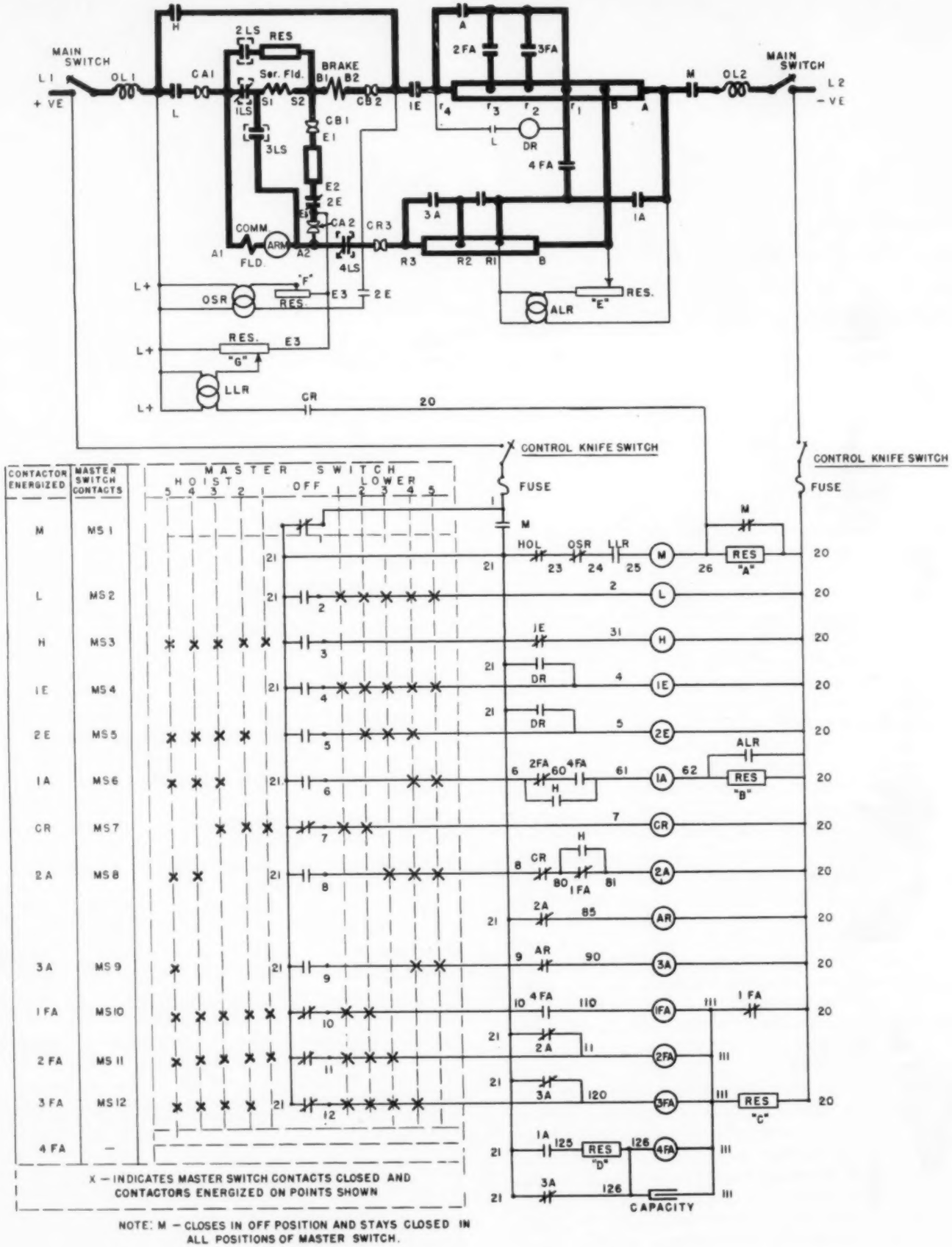

Figure 1 — Connection diagram for dynamic braking, lowering, and hoist controller.

2. MAXIMUM LOWERING SPEEDS

To obtain the lowering speed with light hook, as high as the full load speed, a double coil magnetic voltage relay is introduced. The relay is termed Accelerated Lowering Relay designated ALR. The connections of the relay will be clear from the control diagram in Figure 1. The two coils are located on the same core and connected additively, energized by the voltage drops across the resistance steps (R1-B) and (B-A). The variable rheostat connected in one coil circuit is meant to adjust the setting of the relay.

When the motor has to produce motoring torque to lower empty hook or light loads, the currents in both the resistance steps (R1-B) and (B-A) will be in the same direction, and the relay will pull in as soon as the motor is switched on to the line. The relay remains pulled in for all points of the master switch as long as the load is non-overhauling. The relay controls the resistance contactors 1A and 4FA. Its normally open contacts, marked ALR, shortcircuit the holding resistance "B" for 1A contactor coil. As long as relay ALR is pulled in, its contacts ALR short out the control resistance "B" and allow 1A contactor to go in and close its main contacts 1A connected across the main resistance steps (R1-B) and (B-A) combined.

For motoring loads, therefore, 1A contactor gets energized on the fourth notch lowering of the master switch. The spring-closed contactor 4FA remains energized throughout for all the non-overhauling loads. With 1A contacts closed and 4FA contacts open, the resistance steps (R1-B) and (B-A) are paralleled. The motor armature is connected directly to the power lines, while the series field gets maximum field weakening, having 2.15 per unit resistance in series, which gives high light hook lowering speeds. However, as soon as the load becomes overhauling, the current through the resistance step (R1-B) reverses, while the current through the step (B-A) remains in the same direction, but decreases in magnitude. This is because the motoring torque changes over to dynamic braking torque due to motor becoming a generator because of the overhauling load.

Under that condition, voltage drops across the two coils of the relay ALR opposite each other and the relay becomes a differential relay. Depending on its setting, the relay will drop out when the load becomes sufficiently overhauling. The relay is set to drop out for ¼ full load on the hook with the master switch on the second notch.

When ALR drops out, contactor 1A cannot pull itself in because of the holding resistance B in series with its operating coil. On the fourth notch of the master switch, therefore, as soon as 3A contactor is energized and pulled in, 4FA contactor drops out, because it cannot get its holding power over the auxiliary contacts of 1A, which remain open. 4FA contactor being spring-closed, its contacts 4FA at once close, which parallels the resistance steps (R1-B) and (B-R1), while resistance (B-A) remains as line resistance. This gives about 1.83 per unit resistance in the field circuit, to give smooth lowering with overhauling loads. The relay ALR can be adjusted to drop out for any desired overhauling load by adjustment of the variable rheostat "E" and the relay armature spring tension. The relay ALR is provided with a magnetic shunt to prevent it from pulling in again once it has dropped out during the working cycle.

One single relay can thus be used for all sizes of motors and crane capacities.

3. MOTOR STABILITY

A mill type direct current series motor, so to say, rebels against its operation as a shunt motor with weakened field, as is the standard practice with magnetic hoist controllers during lowering sequence. With the field weakened beyond a certain limit, mill type series motor develops less torque when it is working as a generator to create dynamic braking action than when it works as a motor at that current. This is because at high armature currents with weakened fields, the interpoles get saturated, and the armature reaction tends to weaken the effective field strength in case of generator action. Therefore, beyond a certain maximum load for a fixed field current, an unstable condition sets in, which tends to become cumulative when once started, causing a runaway condition. The stability limits for d-c series motors and the best remedy to be applied, have been fully discussed in a paper by G. W. Haumann and W. P. Smith, in A.I.E.E. Transactions, Vol. 65, pp. 454, July, 1946. It is shown therein that a permanent resistance in series with the dynamic braking motor loop circuit, connected direct to the line, of a magnitude of about 0.15 per unit will provide sufficiently increased stability with heavy loads without decreasing the light hook speed to any great extent.

Due to the inherent stability limitations, therefore, care is taken with all standard controllers to see that the field with light hook is not weakened beyond 50 per cent of its full load value, because with 50 per cent field current, the motor operates already near to its stability limit while handling full loads.

To safeguard against the above mentioned possibility, most standard controllers provide a permanent resistance in the armature circuit in lowering direction. The introduction of such a resistance naturally reduces the light hook speed, and adds an additional danger point which may any time cause an armature loop open circuit due to a break at that point.

In the circuit described in Figure 1, the introduction of relay ALR automatically introduces the line resistance step (B-A) for all overhauling loads. The introduction of the resistance step (B-A) changes the distribution of armature current between the motor field circuit and the power lines. More current is forced through the motor field, which thus is automatically strengthened, overcoming to some extent the field weakening effect of armature reaction. The stability limit is thus increased, and heavier loads can be handled with safety.

4. SAFE AND SMOOTH BRAKE OPERATION

The control relay CR, as shown in Figure 1 is a mag-

netic time delay relay. It serves as an accelerating relay during hoisting and a brake control relay during lowering sequence. If the master switch is suddenly moved to its last notch, relay CR gets disconnected from the third notch onwards. However, the relay does not allow the field weakening contactor 2FA which is interlocked with 2A contacts to drop out, unless the relay itself times out. This gives sufficient time to the series brake to lift completely before the field is fully weakened.

If on the contrary, the master switch is suddenly brought to its "off" position from its final point, the decelerating relay DR, also a magnetic time delay relay, comes into operation. The relay DR pulls in as soon as 1FA contactor drops out. Its two sets of contacts give direct power to contactor coils of 1E and 2E. Thus the contactors 1E and 2E do not suddenly drop out unless the relay DR has timed out. This gives time for the motion to be controlled by the motor dynamic braking action before the brake drops to hold the load. The brake has thus to do only a small part of the job in arresting the motion, which reduces the jerks on the crane and increases the life of the brake itself. This protection becomes effective even in case of power failure or plugging of the motor by sudden reversal of the master switch from lowering to hoisting motion.

5. SELF-PROTECTION AGAINST ABUSE AND OVERSPEEDING

The interlocking between contactors and relays is so provided that the panel always goes through its proper sequence irrespective of the method of moving the master switch handle. The contactors so operate that during lowering, the field is first weakened and the armature then strengthened, which gives a smooth acceleration from one speed step to another. If during lowering at high speed an armature contactor suddenly opens out, the corresponding field weakening contactor gets energized, strengthening the field proportionately and balancing the speed at once. The interlocking is such that failure of a contactor or a relay does not cause any dangerous speed change at any point. Each contactor operates only once in one cycle of operation, giving a straightforward control system.

However, every hoist controller has an intrinsic danger in itself if the armature dynamic braking loop opens out when heavy loads are being handled. This would cause enormous overspeeding, the safety against which depends only on the alertness of the crane operator. Often it may happen that though the driver is alert enough to bring the master switch quickly to its "off" position, the racing has advanced so far that the brake is no longer able to hold the load. These accidents frequently occur on overhead cranes, causing serious damage. To provide against that contingency, the relay OSR—termed "Over-Speed Relay," and the relay LLR —termed "Limit Lowering Relay," are introduced as shown. Both are voltage relays with double coils, of type similar to the relay ALR already described.

The relay OSR is so connected that it supervises the condition of dynamic braking circuit of the motor. The dynamic braking circuit fails if there is a break in the armature loop. The most likely source of trouble is the trolley cross bar collector for the armature, marked CR3 in Figure 1.

Both the coils of the relay OSR are designed to pull the relay in, when 40 volts are applied against the coil terminals. One coil (the top coil in Figure 1) is connected in series with a variable rheostat "F", to the main contacts of contactors L and 2E in such a way that it comes across the armature of the motor. The other coil (the bottom coil in the diagram) is connected over normally open auxiliary contacts of the contactor 2E, to the main contacts of contactors L and 1E in such a way that it comes across the series field and the series brake during the lowering sequence.

The tapping on the rheostat "F" is so adjusted that the relay OSR pulls in when about 260 volts appear across the motor armature. If there is a break in the armature circuit beyond the motor terminal A2, the dynamic braking action fails and the load begins to race downwards. As the series field circuit is still energized and the armature accelerates due to the load, voltage appears across its terminals, which is impressed on the relay coil of OSR. As soon as the voltage reaches 260 volts the relay OSR pulls in. Its normally closed contacts OSR which control the coil of the main line contactor M open out and de-energize the coil M at once. The contacts of M drop out and the whole panel is de-energized, dropping the brakes which hold the load even before it has time to accelerate to any extent. The action is so fast that the hoist does not seem to accelerate at all.

Another source of trouble is the accidental turning over of the series type overhoist limit switch, denoted by contacts 1LS, 2LS, 3LS and 4LS, while heavy loads are lowered. The limit switch turns over at once if its counterweight rope, which is an essential part of the switch, snaps or somehow gets free from its anchorage. When the limit switch turns over, the contacts 1LS and 4LS, which remain normally closed, open out and the contacts 2LS and 3LS close. The main connections then become such that with overhauling loads on the hook, the dynamic braking action of the motor fails, and the load begins to race downwards. Under that condition the bottom coil of the OSR relay automatically gets connected across the limit switch resistance step (R_{20}-R_{21}). The value of resistance (R_{20}-R_{21}) is generally selected of the same magnitude as the dynamic braking resistance (E1-E2) shown in Figure 1, giving a voltage drop across it of at least 65 volts. This voltage is therefore impressed on the relay coil of OSR, set to pull in for 40 volts. The relay therefore pulls it at once and de-energizes the whole control panel, by opening out the main line contactor M, and prevents any possibility of the load racing downwards.

The bottom coil of the relay is interlocked with 2E auxiliary contacts, so that it permits the limit switch to automatically reset itself when once it has operated against overhoisting. This can be done only in the first notch of the master switch. The relay OSR thus protects the hoist against dangerous overspeeding, if the dynamic braking action fails due to one or the other fault described above.

The relay OSR also supervises the condition of the series field cross-bar collector, marked CB2. If this collector makes a bad contact, the series field is reduced

CONTACTORS			RELAYS		
NOMENCLATURE			NOMENCLATURE		SETTING
M	CIRCUIT BREAKER		HOL	HOIST OVERLOAD	LOAD CURRENT TO TRIP — 250%
H	HOIST	(L-H) - (H-IE)	OSR	OVER SPEED	250 VOLTS TO PULL
L	LOWER	MECHANICALLY INTERLOCKED	LLR	LIMIT SWITCH LOWERING	200 VOLTS TO PULL 70 VOLTS TO DROP
IE			CR	CONTROL	0.75 SECOND TO DROP
2E	DYNAMIC BRAKING		DR	DECELERATION	0.2 SECOND TO DROP
IA	3RD HOIST	ACCELERATION	ALR	DIFFERENTIAL	1/3 HOOK LOAD TO DROP
	4TH. LOWER LIGHT HOOK	FIELD WEAKENING	AR	ACCELERATION	0.5 SECOND TO DROP
2A	4TH HOIST	ACCELERATION			
3A	5TH. HOIST				
IFA	3RD. LOWER	FIELD WEAKENING			
2FA	4TH. LOWER				
3FA	5TH. LOWER				
4FA	4TH. LOWER OVERHAULING				
1LS 2LS 3LS 4LS	OVER-HOIST LIMIT SWITCH CONTACTS.				

SYMBOLS	
	MAIN CONTACTS NORMALLY OPEN
	MAIN CONTACTS NORMALLY CLOSED
	AUXILIARY CONTACTS NORMALLY OPEN
	AUXILIARY CONTACTS NORMALLY CLOSED
	TROLLEY CROSS-BARS & COLLECTORS

CONTACTOR SEQUENCE											
		HOIST				OFF	LOWER				
M	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
H	⊗	⊗	⊗	⊗	⊗						
L							⊗	⊗	⊗	⊗	⊗
IE							⊗	⊗	⊗	⊗	⊗
2E	⊗	⊗	⊗	⊗				⊗	⊗	⊗	⊗
IA	⊗	⊗	⊗							⊗	⊗
2A	⊗	⊗							⊗	⊗	⊗
3A	⊗									⊗	⊗
IFA	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗			
2FA	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗		
3FA	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	
4FA	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗		
NOTCH	5	4	3	2	1	OFF	1	2	3	4	5

NOTE: CONTACTORS 'IA' AND '4FA' ARE ELECTRICALLY INTERLOCKED. 'IA' IS ENERGIZED FOR LIGHT HOOK LOADS WHEN 'ALR' RELAY REMAINS ENERGIZED. FOR OVERHAULING LOADS BOTH '4FA' AND 'IA' CONTACTORS DROP OUT FROM 4TH. NOTCH OF THE MASTER SWITCH, WHEN 'ALR' RELAY HAS DROPPED OUT.

RESISTOR STEPS		PER UNIT OHMIC VALUES
A B	LINE RESISTANCE	0.34
B r_1	FIELD RESISTANCE — PERMANENT	0.68
r_1 r_2	FIELD WEAKENING — 3RD. STEP	0.34
r_2 r_3	FIELD WEAKENING — 2ND. STEP	0.68
r_3 r_4	FIELD WEAKENING — 1ST. STEP	0.34
E_1 E_2	DYNAMIC BREAKING	0.51
B R_1	ARMATURE ACCELERATION — 1ST. STEP	0.17
R_1 R_2	ARMATURE ACCELERATION — 2ND. STEP	0.34
R_2 R_3	ARMATURE ACCELERATION — 3RD. STEP	0.17
TOTAL FIELD RESISTANCE — LIGHT HOOK LOAD LOWERING — 1A' CONTACTOR ENERGIZED		2.15
TOTAL FIELD RESISTANCE — OVERHAULING LOAD LOWERING — 4FA' CONTACTOR DE-ENERGIZED		1.83

NOTE:

1 PER UNIT OHM: $\frac{\text{RATED VOLTAGE}}{\text{RATED FULL LOAD MOTOR CURRENT}}$

Figure 2 — Contactor sequence, relay, and resistance steps tables are given in this diagram.

which tends to increase the speed beyond safe limits. If the cross-bar collector breaks or sticks up making an open circuit, the series field is removed. This drops the brake at once, but the armature, being still connected to the line, gets a heavy current kick, which is removed only after the overload relay in the line functions. The relay OSR protects the armature under those conditions, because as soon as the voltage drop across its bottom coil goes above its pre-set value, the relay operates and disconnects the motor from the line instantaneously.

It is pointed out above that the overhoist limit switch can be reset to its working position after its operation with the master switch in only the first notch lower position. This is an advantage, because in many cases the crane driver out of habit, just throws the controller handle to its end position in trying to reset the limit switch. It often happens that the panel has accelerated to its final position by the time the limit switch resets. This brings the armature of the motor direct on the line, giving a heavy current kick. The relay OSR prevents this condition from occurring, because it becomes impossible for the driver to reset the switch beyond first notch lower point of the master switch.

The relay LLR is provided to back up the relay OSR and to perform certain other functions. It will be observed from Figure 1 that if the cross-bar collector CA2, connecting 2E contacts to the armature terminal A2 breaks, or if the limit switch wound type resistance (R_{20}-R_{21}) burns out and an open circuit is formed, the relay OSR becomes ineffective. The above faults frequently do occur on an overhead crane.

The top coil of the relay LLR is connected across the variable taps of the rheostat "G" which itself is connected parallel to the top coil of relay OSR. The tapping of rheostat "G" is so adjusted that when the voltage across it falls down to 70 volts, the relay drops out. The relay is first pulled in by its bottom coil, connected across the lines as shown in the diagram. The coil is designed to pull in the relay at 200 volts. It is controlled by normally open contacts CR of the control relay CR. In the "off" position of the master switch, CR relay is energized, closing its CR contacts, which energizes the bottom coil of relay LLR which also pulls in, if the line voltage is at least 200 volts.

The normally open contacts marked LLR of the relay LLR control the coil of the main line contactor M. Therefore M cannot go in unless LLR is first pulled in. On the third notch lower or the fourth notch hoist, CR times out and opens its contacts CR which disconnects the bottom coil of LLR relay. However, before CR times out, the armature has accelerated so far that its back emf is sufficient to keep LLR pulled in due to the top coil, and permits the hoist to function.

However, if the trolley cross-bar collector CA2 is broken, the relay LLR drops out, when CR relay times out and prevents the hoist from functioning. Similarly if the limit switch resistance is broken, which becomes difficult to be detected, relay LLR takes over the overspeeding protection in case of the accident of limit switch turning over during lowering, because under that condition the LLR will drop out the moment the limit switch tends to turn over.

Another important function of the LLR relay is that it supervises the back emf of the motor armature. If due to some defect or combination of ground faults, the series field gets shorted though the power goes through the series brake, the motor tends to lose its back emf and begins racing down. As soon as the back emf goes below 70 volts, the relay LLR opens out and de-energizes the whole system. LLR relay however becomes effective only from the third notch onwards of the master switch in the lowering direction.

SUMMARY

1. The hoist controller shown in Figure 1 maintains the fundamental features of the standard magnetic hoist controllers. The number of contactors and relays is kept about the same as in most of the controllers designed by manufacturers. The control circuit is also simple and straightforward. The contactors and relays operate only once during one complete cycle of operation, either hoisting or lowering.
2. During lowering, armature circuit has two loops without any intervening contacts. This increases the safety of the circuit, as chances of armature loop open circuit are reduced.
3. The main circuit is based on five trolley cross-bars and collectors. This has the advantage that it eliminates the sneak circuit obtained at the overhoist limit switch point, if the hook is allowed to go into the limit switch and the master switch kept in first notch hoist. The load then begins a pumping action up and down about the overhoist limit switch, as is the case with all controllers provided with a motor armature shunt point, having four trolley cross-bars. As a matter of safety, armature is normally provided with two trolley cross-bars in parallel in most standard controllers. This precaution becomes unnecessary with the controller proposed here.
4. A voltage relay, termed ALR, permits the hoist to operate with maximum speeds for all loads from empty hook to maximum overloads that the crane can lift. The stability of motor operation is also increased to the greatest extent as a line resistance is added automatically for overhauling loads, giving the best and the most up-to-date method of raising the stability limit. The above functions are obtained without addition of extra resistance steps and contactors in the circuit. One relay can be used for all the crane sizes.
5. Automatic protection against overspeeding due to failure of dynamic braking action of the motor due to various possible conditions discussed above, is provided by addition of two simple relays OSR and LLR. Except for the break in the motor armature itself, an exceptionally rare occurrence causing an open circuit, all other contingencies are provided against.
6. Heavy current kicks on the armature due to faulty controller operation or failure of series field while lowering are automatically prevented because the motor gets disconnected instantly the trouble shows itself.
7. The controller is fully protected for proper sequence operation with well defined resistance steps which can be adjusted to suit the speed requirements of particular jobs. Failure of a contactor to function properly does not cause any dangerous overspeed. If the main line voltage is too low, say below 200 volts, the panel fails to function to draw attention of the operator. This provision helps in many cases where due to subsequent load additions the d-c bus voltage goes down, resulting in overloading of crane motors due to increase in time rating.

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MAY 2 and 3, 1949

Crane Block, Limit Switch and Hoist Cable Failures

. . . . proper design and operation of the limit switch will prevent many hook block failures . . . .

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▲ ELECTRIC overhead traveling cranes have undergone many improvements in design. The Association of Iron and Steel Engineers have sponsored standard specifications for heavy duty overhead traveling cranes since 1909, and at the present time another revision is under consideration by the Board of Directors of the group.

The subject of this talk refers to three items in these revised specifications that received a thorough analysis before they were rewritten to comply with good practice on modern cranes. These three items are grouped because a limit switch failure usually results in the hook block being pulled up against the trolley frame, breaking the cable and dropping the block. To better understand this problem, a review of the workings of the hoisting mechanism of the crane should be of assistance.

THE MOTOR

The great majority of steel mill cranes are powered with direct current motors. This type offers certain advantages in torque, ease of control, brakes and operating characteristics over the alternating current motor drives. Further, these motors as used on the hoist are series wound which type gives the greatest starting torque and the most simple control since there is no shunt field to handle. Due to the absence of a shunt field, which would create a flux of some constant value and thereby have a fixed influence on the motor speed, the restraining force to limit the motor speed comes from the series field. This field, as the name implies, is in series with the armature, and when heavy loads are on the crane the heavy armature current flows through the series fields and the motor speed has a value of perhaps 500 rpm. But if the load is removed from the crane hook, the motor load, hence the current, is reduced and the speed may rise to 1200 rpm or greater. Figure 1 shows the speed load and torque load relations on a 65 hp series wound crane motor which illustrates this speed characteristic. Note that for loads of less than 50 amperes or about 15 hp, the motor speed is in a run-away condition. This characteristic is often overlooked in the application of limit switches.

Another characteristic of this type of motor that has an important bearing on limit switch operation is the maximum torque. As an example, the AISE No. 12 Frame standard motor has a crane rating of 65 hp and a torque at full load of 525 foot-pounds at a one foot radius. It has a maximum torque at the same radius of 2,625 foot-pounds.

If, for purpose of illustration, we consider this motor installed to drive the hoist motion on a 20-ton crane with a full load hoisting speed of 50 fpm, we would find the gear ratio from motor pinion to drum gear about 14.44 to 1, the block reeved with 4 parts of 6 x 37 strand improved plow steel cable 7/8 in. diameter which has a breaking strength of 30.5 tons, and the factor of safety on the ropes, so far as the lifted load is concerned, of 6.1. By calculating the pull on the rope with a maximum torque of 2,625 foot-pounds, we find it to be about 70 tons; hence, if the hook block is pulled against the trolley frame, the cable will break. Note that this maximum torque is 5 times the normal torque required to lift the rate load of 20 tons, and that under this condition the pull is not divided among the parts of cable as the sheaves are not free to move.

Modern gears on cranes are determined by a series of formulae which take into consideration both strength and wear. The wear factor usually predominates and results in gearing such that, if tooth strength only is considered, the factor of safety with normal full load is about 10. Hence, the gears are stronger than the cable.

CABLES

The standard diameters of hoisting cables used in cranes are 1/2, 5/8, 3/4, 7/8, 1, 1 1/8, and 1 1/4 in. The accepted

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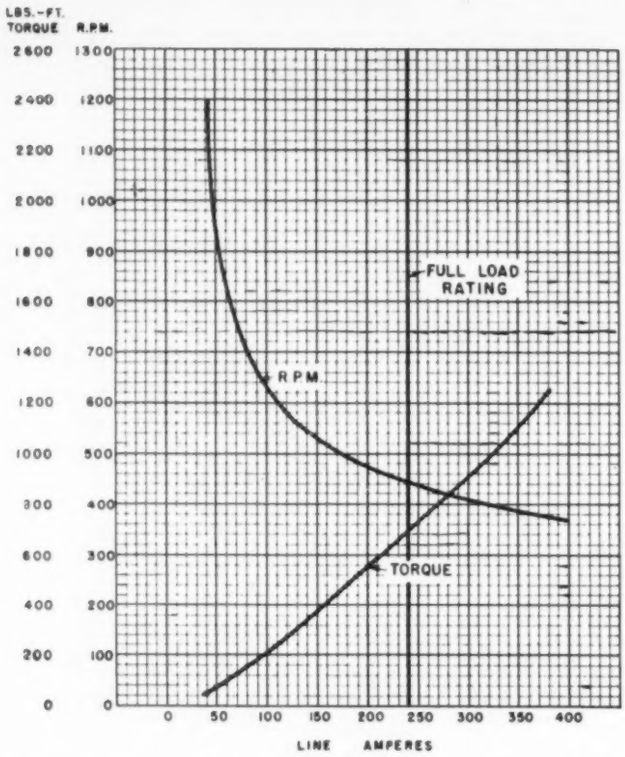


Figure 1 — Characteristic speed and torque curves for a 50 hp (60 minute rating) mill motor. These AISE mill motors are used for both mill and crane service. When this motor is used on crane hoist service it is usually selected on the basis of the thirty minute rating which in this particular case is 65 hp.

construction of these cables is the 6 x 37, which means each strand consists of 37 wires and 6 strands are used to make up the cable. Other than for use on hot metal cranes they are constructed around a hemp center which helps retain the lubrication on the individual wires.

When in service, the cable undergoes a series of bending stresses that bear a relation to the diameter of the hoisting drum and to the sheaves over which the cable is run. It has been determined by experience that cable life is also dependent on the construction of the cable in relation to drum and sheave diameters. Experience, plus many laboratory tests, have set up minimum drum and sheave wheel diameters to use with types of cable, and for crane use a minimum diameter equal to 30 times the diameter of the rope has been set as the standard for the 6 x 37 construction. On the few cranes using the 6 x 19 construction, the minimum diameters have been set at 45 times that of the ropes.

For many years the design of the grooving in the sheave wheels was not thoroughly analyzed. In cooperation with the wire rope manufacturers the Association of Iron and Steel Engineers developed a standard grooving as well as diameters for different sizes of cables. This grooving takes into consideration the manufacturing tolerances used by the makers, also the slope of the sides and depths so as to reduce cable wear to a minimum and have enough radius in the groove to prevent pinching. These standard sheave wheels are shown in Figure 2.

The design of the hook block itself has also received a thorough study and, in addition to the standard sheave wheels, they are so designed as to prevent the ropes from coming out of the grooves.

The above items are mentioned due to their effect on cable life. The new cable has a known breaking strength the worm cable has not. Plant maintenance men have their own methods of cable inspection and rules as to when cables should be replaced. Some count the broken wires in a lay, some use their judgment on the degree of wear, but none can determine how far fatigue has progressed.

Good design has the greatest influence on cable life, and the judgment of the maintenance man has to be taken for the date of cable replacement.

BRAKES

Before discussing the operation of the limit switches, the hoist brake should be discussed. These magnetic brakes are usually of the shoe type and designed with a torque rating such that the brake will hold any load the motor will lift. Modern brakes have a self-aligning feature which distributes the pressure evenly over the entire surface of the lining. These brakes are set by positive spring pressure and the retracting torque developed is directly proportional to the spring pressure, and constant at all speeds of the wheel.

If the 65 hp motor is used as an example, it has a WK^2 or flywheel effect including a 21 in. brake wheel of 143.5 lb ft. Now, if the armature of this motor plus brake wheel is running full load speed of 440 rpm, it has a stored energy equal to 4870 ft lb, and at the runway light load speed of 1500 rpm it has a stored energy equal to 55,000 ft lb. Obviously, the brake which is designed primarily for stopping and holding the load at normal speed will require more time and greater effort to stop the high speed light hook because of the greatly increased stored energy in the motor plus brake wheel at the high speed.

Brake linings wear; so does the wheel. In addition, the lining must absorb the heat caused by the friction between lining and wheel that produces the braking effect. This means that the torque exerted by the brake is not constant over a period of time and maintenance is required to keep its value at its original figure.

In addition, the fact that the hardest duty of the brake may be in stopping the light hook at high speed may be the answer to the short brake lining life in many operations.

The cables, the sheaves, the drum and the brake are all maintenance items that concern hoisting operations. They are related to cable life and limit switch operation and directly bear on chances for a broken cable and failure to hold the load.

HOIST LIMIT SWITCHES

Hoist limit switches are installed on cranes to prevent over-hoisting. Should the hook block continue to raise, it will reach a point where the top of the block will come

in contact with the bottom of the trolley frame, the drum or the upper sheave wheels, depending on the design. When this happens, if the travel has not been stopped the cable is broken and the hook block drops. On a 20-ton crane of mill design, this block may weigh 1200 pounds and, falling from a height of perhaps 30 ft results in damage to block, to anything it hits and, the most serious of all, fatal injuries. Despite all the precautions we are able to take, this type of accident still happens and we have both the human and the mechanical elements to deal with. Experience indicates there is no cure-all that can be applied to keep a crane limit switch functioning 100 per cent, but we do know that good design, as pointed out previously, plus a knowledge of the operation and functions of the equipment, are helps to decrease the number of failures.

The following discussion attempts to point out some of the details on limit switch installations and how they operate. Many factors affecting operation are direct results of design and a well-designed installation does a lot toward successful operations.

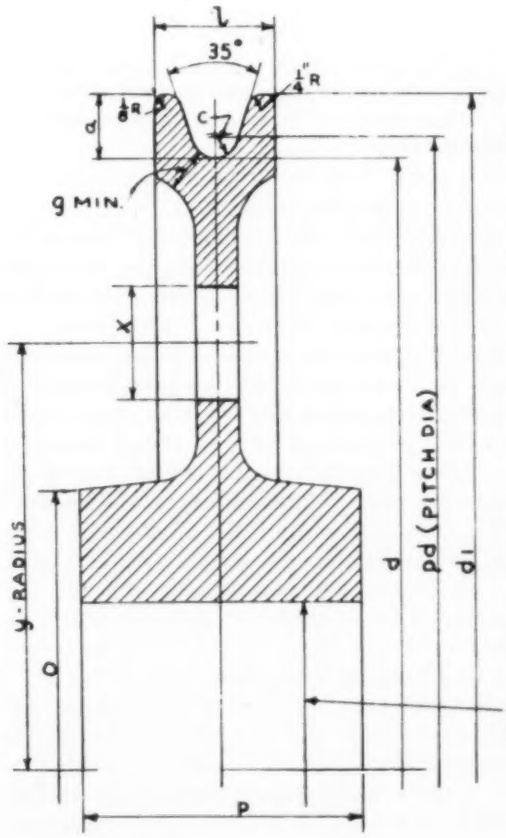
Installation of the limit switch—In order to have the limit switch function properly, it is necessary to consider the mechanical details in the mounting design, which is a function of both the specifications for purchase and the layout by the crane builder.

During the past years, many crane trolleys were designed so that the limit switch operation was dependent on a cable running over two or more sheave wheels, as shown in Figure 3. These wheels, usually of small diameter, each had to be supported on two bearings which were difficult to lubricate due to the fact that the shaft only rotated when there was an operation of the switch. In addition, the impact of the block on the weight at high speed operations often threw the cable out of the groove in the wheel and prevented operation. There are many cases on record where the cable was thrown out of the groove and became jammed between the wheel and the bearing support. In addition, the shaft may be bound to the bearings due to lack of lubrication so that it will not turn. This type of design is not recommended due to its unreliable operation.

A variation of this design uses rods and bell cranks to replace the cable and sheave wheels. The several parts must be kept lubricated and the chances for lost motion and fouling of the parts may affect the operation.

Figure 4 shows an improvement in the layout and one of the designs recommended in the standard crane specifications. In this, the operating weight is kept in position by guides on the idler cables and the control cable from the weight to the limit switch extends directly to the operating arm. This is a preferred arrangement. Some operators object to the guided weight, claiming that a swinging block may hit the weight a glancing blow and tilt it before raising it, thereby delaying the action of the switch. Another objection is that many cranes do not have idler cables and the guide must be placed around a moving cable and it may catch on the strands and prevent limit switch operation.

Figure 2 — AISE standard sheave wheels for cranes are given in this table.



DIMENSION	WHEEL CLASS - A.I. & S.E.												
	S 15	S 18¾	S 20½	S 22½	S 24½	S 26¼	S 28½	S 30	S 32½	S 33¾	S 37¾	S 37½	S 41½
ROPE SIZE	½	⅝	⅝	¾	¾	⅞	⅞	1	1	1⅛	1⅛	1¼	1¼
a	¾	15/16	15/16	1⅛	1⅛	1 5/16	1 5/16	1½	1½	1 11/16	1 11/16	1⅞	1⅞
c	9/32	11/32	11/32	13/32	13/32	31/64	31/64	35/64	35/64	39/64	39/64	11/16	11/16
d	14½	18⅛	19⅞	21¾	23¾	25⅜	27⅝	29	31½	32⅝	36⅝	36¼	40¼
d1	16	20	21¾	24	26	28	30¼	32	34½	36	40	40	44
pd	15	18¾	20½	22½	24½	26¼	28½	30	32½	33¾	37¾	37½	41½
g	½	⅝	1	¾	1¼	⅞	1¼	1	1¼	1⅛	1 7/16	1¼	2
l	1⅝	2	2	2¼	2¼	2½	2½	2¾	2¾	3	3¼	3¼	3¼
o	8	9½	9½	11	11	13	13	14	14	15½	15½	15½	15½
p	4	4¾	4¾	5	5	5½	5½	5½	5½	5½	6	6	6
No. WEB HOLES	4	4	4	4	4	4	4	4	4	4	4	4	4
x	1½	1½	2	2	2	2½	2½	3	3	3	3	3	3
y	5½	7	7¼	8¼	8½	9½	10	10¾	11¼	12	12¾	12¾	13¼

To overcome this, the design, using a free swinging hinged steel bar that extends through the hoisting cables directly above the blocks, has been developed, as shown in Figure 5. With this design the bar is raised regardless of the position of the block and no guide contacts with the hoisting cables are required. Figure 6 shows the position of the bar with (a) the limit switch set and (b) with the switch tripped.

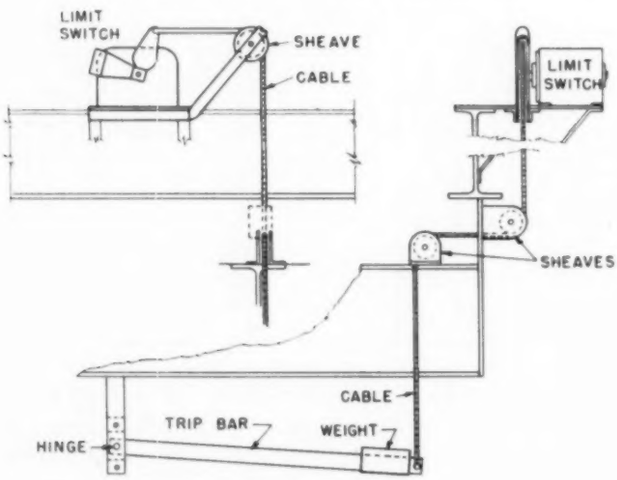
Requirements for hoist limit switches—The recent revision of the Standard Specifications for Steel Mill Overhead Traveling Cranes contains the following requirements for limit switches:

A. "Each hoist motor shall be equipped with a standard dynamic braking limit stop connected directly in the motor circuit, to prevent over-travel in hoisting. The limit stop shall have a back-out circuit for lowering hook block from hoist master controller. Resistor shall be of the unit type with nonbreakable corrosion resisting elements mounted in standard mill type box. The limit stop shall be located so as to be accessible for inspection and, if possible, so that it will be operated by the hook block, or load beam, in such manner that no sheave wheels are necessary. Limit switches must reset properly and must be so designed to prevent grounds as far as possible.

B. "An arrangement using a free swinging weighted beam, hinged at one end and having the other end attached to the limit switch operating cable. The trip bar shall be so designed that the cables cannot jump out around the end of the bar which would permit the hook to rise outside the trip bar. The trip bar shall be so designed that no movement of the hoist and trolley can enable the trip bar to be jammed against any part of the crane structure.

C. "A weight directly connected with the limit switch and guided by suitable guides so that twisting cannot occur on the idler cables shall be used if so specified. Cable guides should preferably have replaceable maple wood or bakelite guide blocks to prevent wear on the cable.

Figure 3 — The limit switch cable installation which uses sheave wheels is not effective if the wheel bearings freeze or the cable jumps out of the sheave.



D. "The actuating mechanism of the limit switch must be so placed that it will trip the limit switch in sufficient time under all conditions of hoist load and hoist speed.

E. "If sheaves are used in connection with the hoist limit stop, the pitch diameter shall not be less than 18 times the rope diameter. Cables should be guided through a hole on both ends of the sheave."

The limit switch—The modern hoist limit switch is a double pole, double throw cam operated quick-make and quick-break device, held in the operating position by a weighted arm, as shown in Figure 7. At the other end of the weighted arm the cable is attached, with one end fastened to the bar or weight that is moved by the hook block. When the block raises this weight, it overbalances the weighted arm which moves the mechanism over the cam, and the limit switch snaps over. All modern switches have the feature that they snap open or closed and have no midway position. Figure 8 shows a view of this limit switch with the cover removed. The heavy spring that snaps the switch closed or open when the cam trips the latch can be seen at the left-hand end.

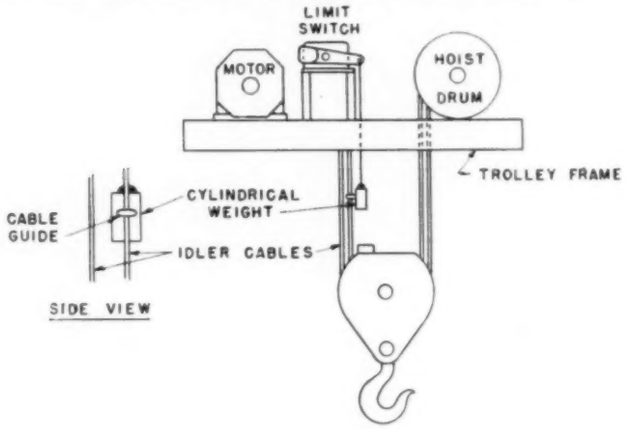


Figure 4 — The design in which the limit switch cable is operated by a weight directly connected to the limit switch was approved by the latest revision of the AISE crane specifications.

The double pole double throw contacts with the arc chutes and blow-out coils are in the center. This particular design has the safety chain which ties the cover to the box which prevents its falling from the trolley during inspection periods.

When the switch operates, it opens the motor circuit cutting off the power which causes the brake to set, and closes contacts that complete a dynamic braking circuit that assists in stopping the motor. Figure 9-A shows an elementary wiring diagram of the motor and limit switch circuits for normal hoisting operations. Figure 9-B shows the same circuits with the limit switch tripped. During normal operations, limit switch contacts Q_1 and Q_4 are closed, and contacts Q_2 and Q_4 are open. When the hoist over-travels and the switch is tripped, contacts Q_1 and Q_4 open to cut off the power to the motor which causes the brake to set, and contacts Q_2 and Q_4 close and complete the dynamic braking circuit through the resistor R. This resistance in series with the motor field and armature can be adjusted to give the degree of dynamic braking required. From Figure 9-B it will be noted that if the resistor should break

or in any manner open the circuit, there would be no dynamic braking effect. For this reason, it is always specified to be of the nonbreakable, corrosion resistant type. The cover is strong enough to support the weight of a man who may use it as a foot stool and is dust-tight to prevent dust accumulations which might result in a ground on the circuit.

The electrical circuit setup for dynamic braking is that of a series generator into a resistor limiting the load. Under most operating conditions, the limit switch is tripped while power is on the motor in the hoisting direction. The field flux does not have time to decay and the build-up in voltage is immediate. However, if the power is removed from the motor circuit before the switch is tripped, the field flux may have time to decay and the voltage must be built up from the residual flux before dynamic braking is effective.

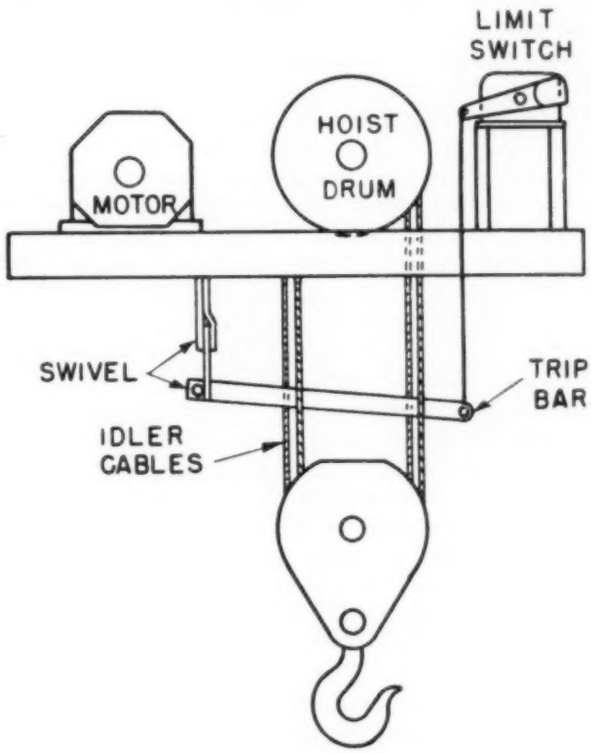


Figure 5 — The use of a limit switch cable with a free swinging bar is the design which is probably used most extensively in steel mill practice.

One of the characteristics of a series generator is that if a certain critical resistance is exceeded, the voltage will not build up from the residual flux. This critical resistance can be exceeded due to:

1. Loose lug or terminal connections.
2. Loose or broken resistor grids.
3. Poor condition electrically of brushes, brush shunts or commutator.
4. Poor condition electrically of limit switch contacts.

If any of the above conditions exist, the crane hoist must be stopped by the brake and if the brake torque is insufficient, the hook block may drop.

At this time, mention can be made of a condition that sometimes happens on overhoisting. If, just as the block engages the limit switch weight the operator plugs his

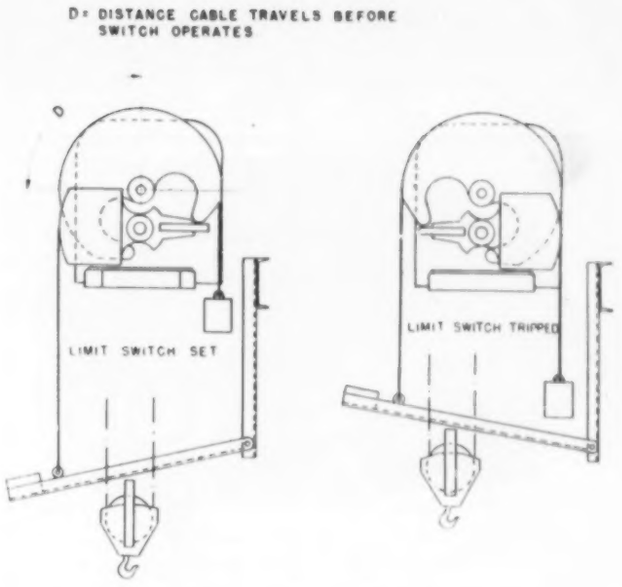


Figure 6 — The weight must travel through the distance D in order to operate the limit switch.

hoist master controller, the hoist will be brought to a quick stop without the brake setting, due to the heavy dynamic braking effect. In one series of tests with light hook at 325 per cent motor speed, this distance varied between 11 and 13 inches plus the weight travel until the switch operated. The objection to this is the high current set up to be broken by the limit switch contacts and a chance of flashing the armature.

There are some dynamic hoisting controls so designed that there is a shunted armature on the first point of hoisting. If the operator allows the hoist to operate the limit switch with his scheme of control, the brake will not set as it is energized through the shunted circuit. Most maintenance men are familiar with this type and either remove the slow speed hoisting feature or make the operator familiar with this condition.

All the foregoing has concerned the single motor hoists. On the hot metal ladle cranes two hoisting motors, operating in parallel, are used. On these cranes the load beam supporting the hooks has its hoisting cables between the main and the auxiliary girders, so if the hoist is raised too high, the load beam tries to lift the auxiliary girders or break the cables. For this type of crane there is a duplex limit stop which contains two switches, either in the same case or in two cases, with coupled shafts so that both motors are disconnected and the brakes set when the switch operates. On this type of crane, the control scheme is often used where the hoist control has the slow speed feature on the first point. Figure 10 shows a view of a duplex limit switch with the cover removed. Note that this switch has 4 double pole contactors.

After the limit switch has been tripped and the hoist stopped, it is necessary for the crane operator to reverse his master controller to lower the hook block. This sets up a circuit through resistors which drives the hoist down, as shown in Figure 9-C. Should a heavy load be on the hook, there is danger of the overhauling action of the load plus the driving power of the motor to com-

bine and cause a sudden drop of the block during the time of travel to the point where the limit switch resets. There are several control schemes to prevent this, and

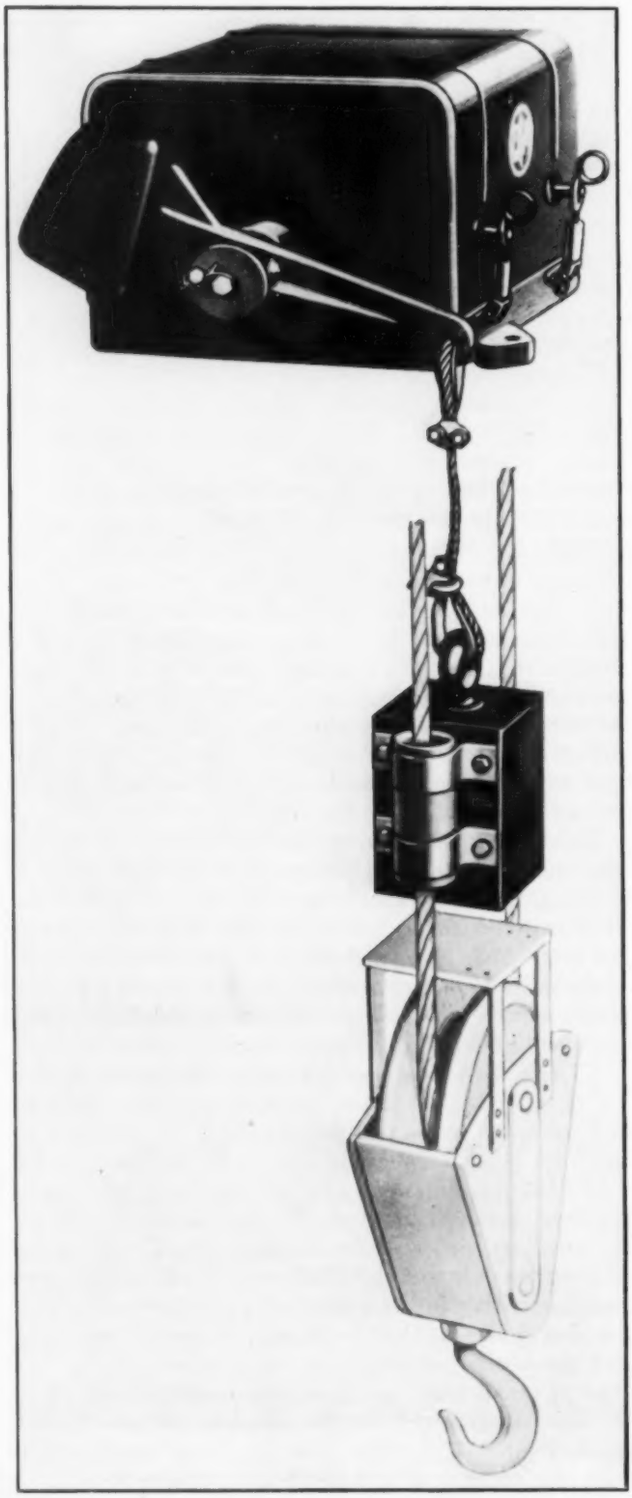


Figure 7 — The limit switch shown is the so-called Youngstown limit switch.

it should not be overlooked in the purchase of crane hoist control.

The foregoing paragraphs have pertained to the various parts of crane hoisting mechanism that concern the life of the cables and the emergency stopping of the hoist. The following paragraphs give further details on the actual operation.

1. Earlier in the paper, the characteristic speed load curve of a series wound mill type motor was shown whose full load speed was 450 rpm. Assume this 65 hp motor to be on a crane hoist with a rated full load hoisting speed of 50 fpm. With a light hook the motor load is under 10 hp and by reference to the curve the motor speed at this load may be 1500 rpm. At this motor speed the hoist will be raising at a speed of 167 fpm, or 2.78 fps.

On this particular crane the limit switch is so located that the weight can travel only 18 in. from the time the hook block first contacts it until it strikes the upper sheave wheels or the trolley frame. The distance the weight has to travel before the limit switch arm operates the cam, varies from 2 to 9 in. in the many designs now installed. If we assume this particular switch has a weight travel of 6 in. before the switch trips, then only 12 in. remain to complete the operation. At a speed of 2.78 fps. the block will travel 12 in. in 0.36 sec. In this short time the switch must trip, the brake be set, and the motor be brought to rest. This time interval is too short and it is doubtful if the block will be stopped before the cables are broken.

This high speed light hook hoisting is the most difficult operation for the equipment, as with normal full load the time available for stopping is increased 300 per cent. These two conditions are similar to those in stopping an automobile. If the car is going at a rate of 10 mphr. it can be brought to an emergency stop in a few feet; but, if going 60 miles per hour, the stopping distance increases as the ratio of the square of the speeds. The same law of mechanics whereby the stored energy is equal to the mass or weight times the square of the speed applies in both cases.

Hence, limit switch weights or bars must be set so that sufficient time elapses after the weight is lifted to allow the motor to be stopped at 350 per cent normal full load speed.

High speed light hook hoisting has not been taken into consideration in many crane installations where the prime consideration was the maximum height loads can be lifted. It is seldom that the manufacturers of limit switches have been consulted to find out what distance the operating cable must travel before the switch operates. It is good practice to find out this distance and by test determine the maximum light hook hoisting speed. From this speed, calculate the distance the block will travel in 0.45 second. To this distance, the cable travel to operate the switch should be added and the result would be the minimum distance the limit switch weight or bar should be set below the trolley frame, upper sheaves or other part of the crane where the hoist block would strike.

On certain crane movements in the plants, there are occasions when loads have to be lifted to a point where the block must be raised into the zone where the limit switch functions. This requires a careful operator and should only be done with permission of a responsible party. There are other operations where the limit switch is used as the stopping control for many lifts. This practice is dangerous and should be controlled. Limit

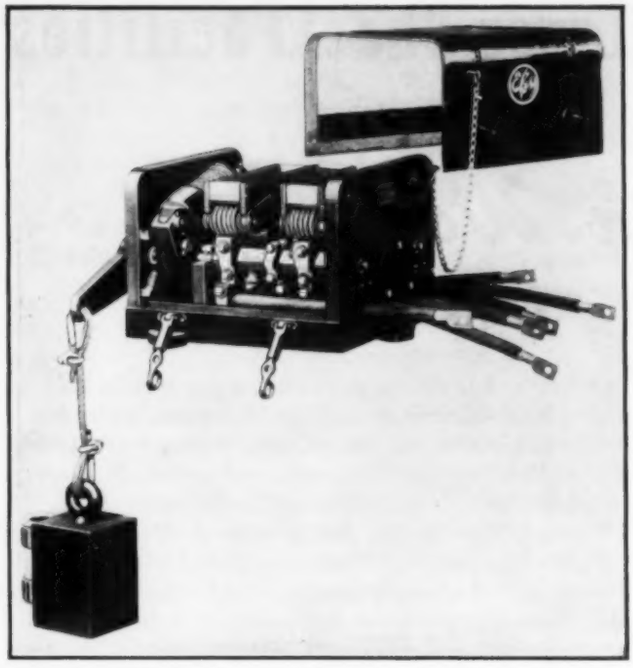


Figure 8 — A Youngstown limit switch with the cover removed is given in this photograph.

switches are placed on crane hoists to prevent overhoisting and operators should insist that they be given a chance to function.

This discussion has been confined to modern limit switches and cranes. There are hundreds of old cranes in operation with obsolete limit switch design and manual controllers. One type of limit switch consists of hinged wooden blocks with carbon contacts. In this type there is always the danger of the hook hitting the blocks a glancing blow and swinging them, with the result that the contacts are not closed. This type of switch depends entirely on dynamic braking, the motor circuits not opening nor the hoist brake setting. The switch, after an operation, must be opened by means of an insulated stick which, in most cases, is the broom kept in the crane cab. This type and several other designs will stop the hoist under most conditions, but from the records of dropped blocks, it is a paying proposition to replace them.

In conclusion, we are all interested in preventing accidents resulting when the hook block falls from a crane. The following suggestions, if followed out, will help minimize these failures:

1. Pay careful attention to the design of the crane and the mechanical details of the limit switch installation. Be sure to have enough travel for the weight to allow the switch to operate.
2. There is no substitute for good maintenance to insure reliable operation. The frequency of inspection may be daily or weekly or even longer, depending on the crane service or its location. This inspection should include a tripping test consisting of two operations. In the first, gradually inch the block so that it raises the weight and trips the switch If this test is successful, lower the block near the ground and, with full speed light hook hoisting, permit the switch to stop the hoist.
3. Have close supervision over the crane operators. One of the practices that contribute to jeopardizing the condition of a limit switch installation is that of using it as a service stop, when it is intended as an emergency safety device. This type of stopping requires many more operations per turn than should be expected during the life of the switch under normal operating conditions. If current peaks of 250 per cent or greater are handled for frequent service stopping, high electrical and mechanical maintenance can be expected and the limit switch installations as a whole may deteriorate, and fail as a safety device.

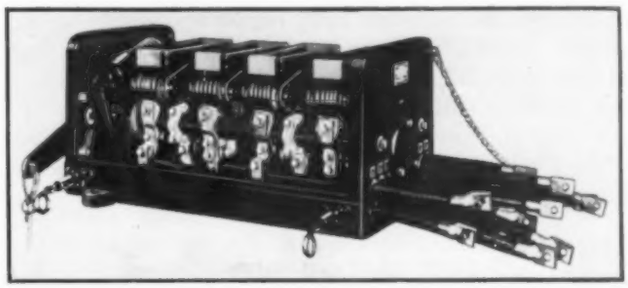
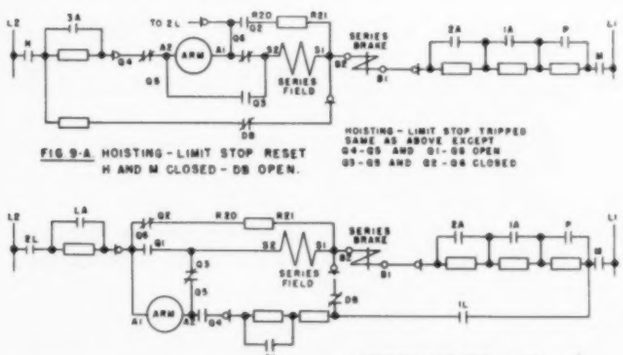
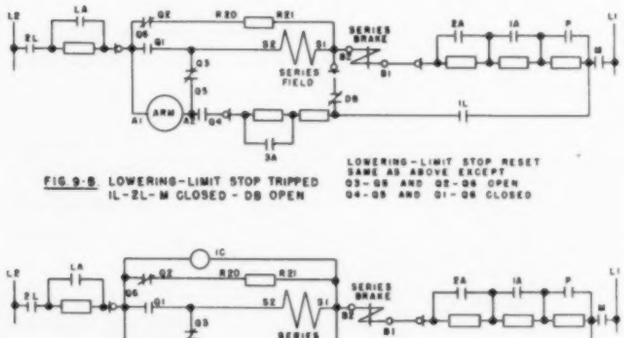
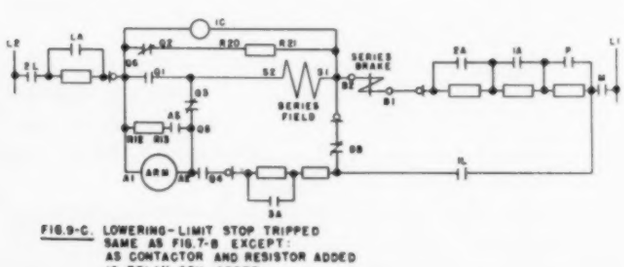


Figure 10 — If the crane has dual hoist motors, a duplex limit switch should be used.

Figure 9 — The hoist motor connections are given in these one line diagrams which illustrate the operation of the limit switch.







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Carnegie-Illinois Modernizes Sheet Facilities

at the Irvin Works

▲ FACILITIES for production of sheet steel have been modernized at the Irvin Works of Carnegie-Illinois Steel Corporation. No increase in district tonnage capacity of this United States Steel Corporation subsidiary is involved, the considerations guiding this program having been improved quality of product and better efficiency of processing. The main innovation of the entire modernization program is that the new arrangement makes possible the production of sheet steel in coil form up until the final operation of shearing to size.

Major additions to existing sheet-steel producing facilities included: an additional slab-heating furnace for the 80-inch hot-strip mill; conveyors and shearing equipment with other auxiliaries added to the existing 80-inch pickling line; a new 56-inch continuous pickler; new shearing equipment in the finishing department; new sheet-coil annealing furnaces; handling units added to the temper mills; and pilers for cold-reduced sheet-shearing lines.

SLAB HEATING FURNACE

A new, fourth furnace has been added to the three that formerly supplied heated slabs to the 80-inch mill. It is a zone-controlled, triple-fired, end-charged, end-discharged, continuous-type furnace. Maximum capacity of the new unit is 105 tons per hour, when heating a double row of cold slabs, 6 to 8 inches thick and 8 feet, 10 inches long, to 2350 F. Design and control features make it possible to heat slabs from 3 to 8 inches thick and 20 to 60 inches wide, and from 60 to 216 inches long to uniform rolling temperature throughout.

The inside width of the furnace is 20 feet and its effective length is 80 feet. It was built to line up with the other three furnaces.

The primary heating zone is separately-controlled and over-and-under fired. The secondary soaking zone, with separate controls, is over-fired. Fuel is coke-oven gas, although the furnace was designed to permit conversion to oil burning in the event of gas failure.

80-INCH RAW COIL PICKLING LINE

New equipment for the 80-inch raw coil pickling line includes a cold water-spray rinse tank, hydrochloric acid dip tank, cold water-spray rinse tank and hot-water dip tank, looping pit, delivery pinch rolls, side trimmer with scrap chopper, inspection table, drag bridle, overhung mandrel-type coiler, driven pallet-type conveyor and scale. Support rolls, wringer rolls, tables, guides, fume-exhaust system, and other auxiliaries complete the installation. An existing dryer, entry pinch rolls and guides, unfolding rolls and upcut shear were completely rebuilt and relocated in the line.

The upcoiler was completely redesigned and altered to permit winding 50,000 pound coils and relocated, and includes new housings, bearings, and 8-inch diameter rolls. Particular attention was paid to the design of this unit to permit changing rolls without dismantling the entire machine.

Equipment for the 80-inch line permits continuous pickling speeds up to 275 fpm. Material 0.050 to 0.250-inch thick and 18 to 77 inches wide is delivered from the line in loosely wound coils approximately 30 inches in inside diameter and 84 inches maximum outside diameter, weighing up to 50,000 pounds. Tightly wound coils are 24 inches in inside diameter by 18 to 77 inches wide, and 80 inches maximum outside diameter, also weighing up to 50,000 pounds.

Normally, the line operates on hot-rolled product 0.070 to 0.150-inch thick, but it is capable of efficiently handling material up to 0.250-inch thick, as described above.

The scale at the exit end of the line is a 50-ton capacity unit of the beam type.

56-INCH RAW COIL PICKLING LINE

The 56-inch raw coil pickling line is designed for continuous pickling and side trimming of hot rolled material 18 to 48 inches finished width and 0.050 to 0.250-inch thick.

Pickled product is delivered from the line in coils 20 to 31 inches in inside diameter, by 55 to 80 inches outside diameter, and weighing up to 42,000 pounds. The line normally operates with material 0.070 to 0.150 inch thick and is designed for most economical operation within this range. Welds that join successive coils to each other are sufficiently strong and free of upset after flash trimming to permit subsequent cold rolling at full mill speed.

Coil-feeding and welding equipment are designed for continuous operation of the pickling section at 230 to 420 fpm, depending upon strip width.

The pickling section includes 280 feet of active pickling length and is divided into four brick and rubber lined tanks, with acid-heating and fume-exhaust systems. The necessary equipment for rinsing and drying has been provided.

All tank linings are at least 12 inches thick. Recesses

were provided at intervals for insertion of steam jets fed from headers outside the tank.

The side trimmer is supplied with means for processing side scrap to charging box side.

An oiling system applies rolling lubricant to the pickled metal immediately before recoiling.

Approximately 50 feet of apron type conveyor conveys coils into the entry line. The exit conveyor consists of approximately 60 feet of apron type conveyor located at floor level. A 50-ton scale weighs finished coils.

RAW COIL CONVEYOR

A continuous motor-driven chain-type conveyor, 575 feet long, transports hot-rolled steel coils weighing up to 20,000 pounds, on side or end, at floor level, from the raw coil storage building to the 80-inch pickle line. The conveyor has a capacity of approximately 100 coils, making a continuous total load of about 750 tons. Speed is 15 fpm controlled by electrical equipment suitable for 30 start-stop operations per hour under full load. The chains are in continuous strands, with the main drive at the discharge end of the conveyor, with a sufficient number of booster drives along the length to keep stresses in the chain within allowable working limits. The master operating control station is near the discharge end of the conveyor, and three emergency-stop stations are located at intervals of about 150 feet. A limit stop is provided to prevent coil travel beyond a pre-determined point at the discharge end, and a second limit stop at the end of the conveyor. The controls are arranged for automatic restarting, if desired, upon removal of a coil which has operated the limit stop.

SHEET ANNEALING DEPARTMENT

Numerous major changes were made to the sheet annealing department in conjunction with the modernization program. One phase of this work included installation of 10 four-stand bell-type sheet-coil annealing furnaces and 22 bases for operations with these furnaces.

The four-stand furnace bases each will accommodate, in a single line, four coil stacks 40 to 48 inches in diameter, with a maximum height consistent with lifting clearance requirements. Stack height is at least 155 inches. Each of the new furnaces weighs approximately 100,000 pounds.

A second operation involved the relocation of sixteen flat-sheet annealing furnace bases. Also, 12 existing flat-sheet annealing bases were altered to conform to the 16 relocated flat-sheet bases. Ten existing furnaces were also altered for operations on flat-sheet bases, including the design, fabrication and installation of exhaust collector piping for each furnace to collect exhaust gases and discharge them outside the sheet annealing building.

Six existing 8-stand coil-annealing bases were altered, by the installation of additional steel supporting members, that permit each base to carry a total load of 480,000 pounds of coils. New removable-type coil stands (8 on each base) were furnished with the necessary changes made to the base structure to secure a solid level support for each stand. Each stand is capable of supporting 60,000 pounds of coils. Improved fans were furnished and installed in each base. Existing fan motors were rewound for higher speed, and bearings were replaced. Provisions were made in the electrical and piping connections to motors and stands for readily disconnecting to allow renewal of the coil stand. Each base was equipped with new distributing lines for controlled atmosphere and electrical controls. Coil stands were constructed with a flat surface on which the inner cover rests to prevent entry of air or furnace gas when admitting 30 cubic feet per hour of controlled atmos-

Figure 1 — Discharge side of the battery of 4 slab reheating furnaces at the Irvin Works of Carnegie-Illinois Steel Corporation. The new furnace, recently added in conjunction with a modernization and expansion program at this plant, is the unit in the foreground.

phere under the cover. Stainless steel inner covers for coil stacks were supplied with the bases.

Steel after the annealing cycle is cooled by air jets around the base, arranged so that the air can be shut off when the furnace base is on.

In addition to the foregoing changes, two of the 8-stand coil-annealing furnaces were altered to increase their effective piling height from 98 inches to 130 inches. The furnace refractory and steel work was changed to increase the height from the parting line to the underside of the refractory roof to about 11 feet 9 inches. The furnaces also were altered for direct firing. Combustion equipment provides a maximum heat input of 7,000,000 Btu per hour, and a normal heat input of 5½ million Btu per hour. Piping was arranged for horizontal exhaust to the outside of the building.

Furnace temperature control was mounted on each furnace. Constant air-gas ratio is maintained regardless of heat input or furnace temperature when firing either coke-oven or natural gas.

A fuel-gas cleaning, drying and distribution system for 250,000 cubic feet per hour of coke-oven gas maximum capacity was installed. Total gas flow is integrated and recorded: flow through branches is indicated and integrated for each of the following three systems:

System No. 1—22 new four-stand coil bases.
System No. 2—6 eight-stand coil bases.
System No. 3—28 flat bases.

ATMOSPHERE DISTRIBUTION SYSTEM

Piping distributes controlled-atmosphere gas, used to protect the steel during annealing, from an existing 8-inch connection to four systems. Flow meters integrate and record total flow, with flows through branches being integrated and indicated for each of the following systems:

System No. 1—22 new four-stand coil bases.
System No. 2—6 eight-stand coil bases.
System No. 3—Group of 12 flat bases.
System No. 4—Group of 16 flat base.

Two existing controlled-atmosphere gas generating machines were dismantled. They were replaced with new controlled-atmosphere, gas-generating equipment, which supplies a gas of different composition than that formerly used. The new gas has been found superior with respect to quality of finished sheets, especially sheets intended for coating.

The new atmosphere gas is largely nitrogen, containing 1 to 5 per cent carbon monoxide and 1 to 5 per cent hydrogen. Alternatively, the generators can supply partially-combusted natural gas containing 10 to 14 per cent hydrogen, and 10 to 14 per cent carbon monoxide.

SHEET TEMPER MILLS

Numerous design changes were effected on sheet temper mills No. 1, 3, and 4. These changes permit processing 20-inch and 24-inch inside diameter, by 78-inch maximum outside diameter, 50,000-pound maximum weight coils on the mills No. 1, 3, and 4, as well as

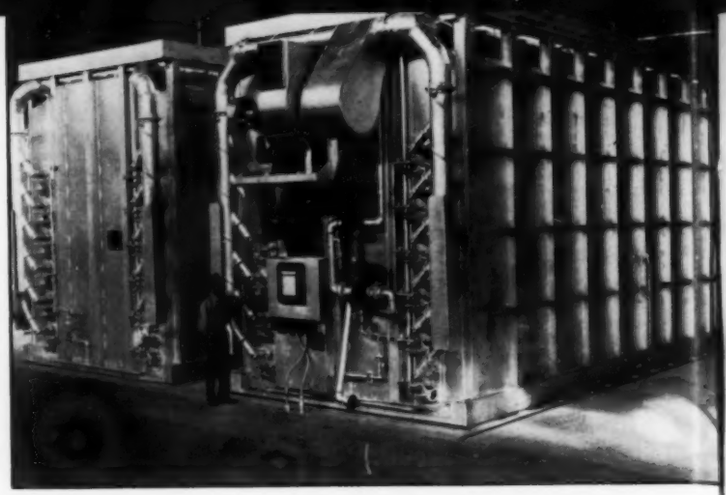


Figure 2 — Two of the new gas-fired radiant-tube-type annealing furnaces. All of the necessary temperature control equipment, and other control mechanisms for these furnaces are mounted on one end of the furnace body as shown on the unit at the right which has been turned 180 degrees to show the arrangement at the control end. Normally the furnace operates in the position of the furnace at the left, with the control instruments at the end of the furnace opposite from the aisle to protect them from possible damage.

individual sheets on mills No. 1 and 3. Three new, improved-type downtilters were installed to receive coils on end from an overhead traveling crane and deliver the coils on their sides onto the center of an apron-type coil conveyor. Three new apron-type power driven coil conveyors stock and convey coils from the downtilter to the uncoiler. The center line of the downtilter to the uncoiler is approximately 42 feet. This work included rearranging of existing sheet-handling equipment on the entry side of mills No. 1 and 4. New equipment was installed or changes made to existing uncoilers to provide means for handling the larger coils at the higher speeds involved. Chocks on the No. 1 mill were altered to accommodate 19-inch diameter work rolls to duplicate changes made to mill No. 3. Mills No. 1 and 4 were speeded up to the maximum speed obtainable with the present mill-drive motor or about 1000 fpm. The present main-drive motor for mill No. 3 was coupled in tandem with the main-drive motor on mill No. 1.

The width of No. 3 mill was reduced from 84-inch to 56-inch roll face, and entry and exit tension roll bridles were furnished. The mill was speeded up to 2500 fpm, by means of new main-drive motors, motor-generator sets, controls, and so on, using existing equipment where suitable. Tension bridles were arranged to permit passing heavy-gage strip over the bridles.

Mill No. 4 was relocated between mills No. 1 and 3, a position formerly occupied by mill No. 2. The screwdowns on mills No. 1, 3, and 4 were speeded up from 0.55 to about 1.35 rpm, using the existing motors and screws.

New mandrel-type recoilers were installed, or changes made to existing recoilers, for mills No. 1, 3, and 4 to handle the larger coils and higher speeds encountered. Individual apron-type chain conveyors about 85 feet long discharge coils from mills No. 1, 3, and 4. A 50,000-pound registering scale with suitable hydraulic coil-lifting cylinders weighs coils on the exit apron conveyor for mill No. 3. Coil lifting cylinders were provided for

weighing coils on exit apron conveyor for mills No. 1 and 4, using relocated existing scales.

SHEARING AND RECOILING FACILITIES

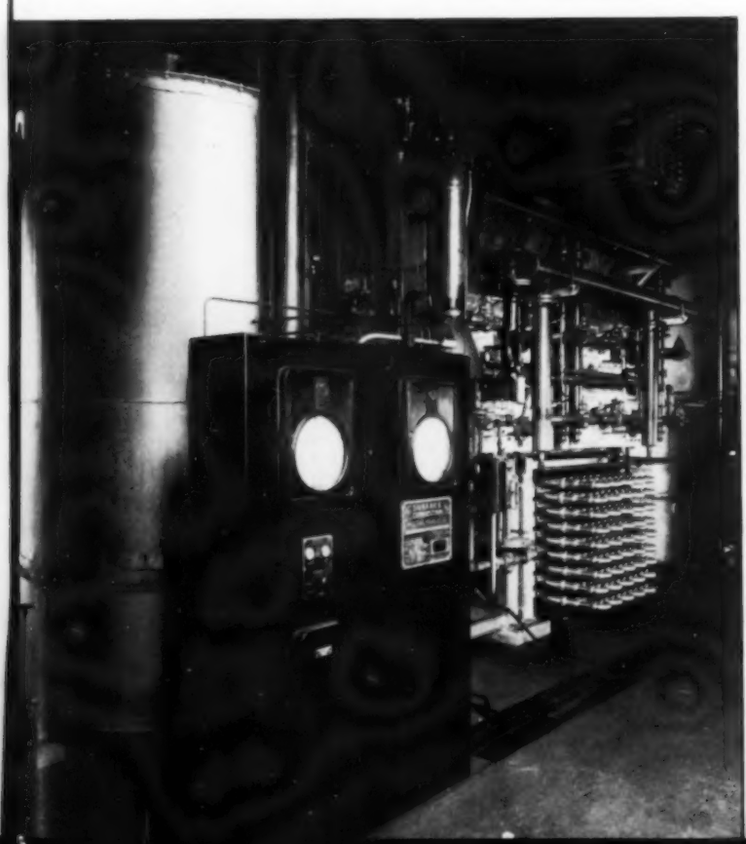
New shearing and recoiling facilities for the cold-reduced product finishing department include a 54-inch, high-speed, side-trimming and sheet-shearing line; an 80-inch slitting and recoiling line; an 80-inch side-trimming and sheet-shearing line; a scrap baller; and scrap trap for conveying side scrap to the scrap baller.

54-INCH SIDE-TRIMMING AND SHEET-SHEARING LINE

Material to be sheared on the 54-inch side-trimming and sheet-shearing line is cold-reduced, annealed and temper-rolled coils of regular carbon grades, 19 gage (0.0429-inch) to 30 gage (0.0123-inch). Entering coils have an inside diameter of 24 inches and an outside diameter of 72 inches maximum. Width may range from 18 to 50 inches maximum. Maximum coil weight handled is 50,000 pounds. The line produces sheets within the length range of 30 to 144 inches in increments of $\frac{1}{16}$ inch, and widths betwen 18 and 48 inches. Operating speed range of the unit is 250 to 1000 fpm.

Major equipment involved in the new line includes an entry ramp; mandrel type uncoiler with coil carriage; looper with photo-electric controls; entry guide; side trimmer; looper with photo-electric controls; drum-type flying shear and leveler; inspection tables; back-up roller leveler; sheet oiler, arranged for withdrawal from the line; prime piler; reject piler; scale conveyor section with 30-ton scale in line with the prime piler; prime runout-conveyor section; reject runout-conveyor section; and complete electrical equipment including a variable-voltage motor-generator set, motors and controls; and an electrolimit gage.

Figure 3 — Partial over-all view of one of the four controlled atmosphere generators that supply inert atmosphere gas to the annealing furnaces.



80-INCH SLITTING AND RECOILING LINE

Cold-reduced, annealed and temper-rolled coils of regular carbon steel grades, 14 gage and lighter, can be handled on the 80-inch slitting and recoiling line. Entering coils have an inside diameter of 24 inches and a maximum outside diameter of 72 inches. Coil widths range from 18 inches, minimum, to 77 inches, maximum, representing a maximum weight of 50,000 pounds. The line is capable of side trimming or slitting coils down to 12-inch minimum width, also for producing small coils for any width by shearing large coils. Inside diameter of the finished coils is 24 inches. Speed of the 80-inch line is 1000 fpm maximum.

Major equipment comprising this line is as follows: entry ramp; mandrel-type uncoiler with coil carriage; looper with photo-electric control; side trimmer and slitter arranged for piercing, with entry guides, a second looper with photo-electric control; tension roll unit; air-operated shear; oilers; recoiler with stripper and carriage; discharge ramp for small coils; complete electrical equipment, including variable-voltage motor-generator set, motors and controls recording linear footage counter; and electrolimit gage.

80-INCH SIDE-TRIMMING AND SHEET-SHEARING LINE

One existing sheet-shearing line was dismantled and (using as basic equipment the flying shear, roller leveler, oiler, conveyors, scale, piler, and so on, from the dismantled line) a new 80-inch side-trimming and sheet-shearing line was constructed.

Cold-reduced, annealed, and temper-rolled coils of regular carbon steel grades, 11 gage and lighter, can be processed on this line. Entering coils have an inside diameter of 24 inches and a maximum outside diameter of 72 inches. Coil widths may range from 18 to 77 inches, with maximum coil weight limited to 50,000 pounds. The line produces sheets 22½ to 180 inches long and 18 to 77 inches wide at a speed of 133 to 400 fpm. The complete line comprises the following major units: entry ramp; mandrel-type uncoiler with coil carriage; looper with photo-electric control; side trimmer; looper with photo-electric control; flying shear and leveler; inspection table; backed-up roller leveler; sheet oiler; prime piler; scale conveyor section and 30-ton scale in line with the prime piler; prime runout conveyor; complete electrical equipment, including variable-voltage motor-generator set, motors and controls; and mountings for an existing electrolimit gage.

A new scrap trap was installed for conveying side scrap to the relocated scrap baller.

The sheet-assorting type piler is capable of receiving 16 to 24 gage sheets, 18 to 77 inches wide by 45 to 180 inches long, from the sheet-shearing lines at an entry speed of 250 to 1000 fpm, and assorting them into prime and reject piles at a speed of 90 to 360 fpm.

With rare exceptions on commercial and industrial installations

Ordinary Fuses and Breakers Do Not Protect Except Against Short-Circuits

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DUAL-ELEMENT FUSES

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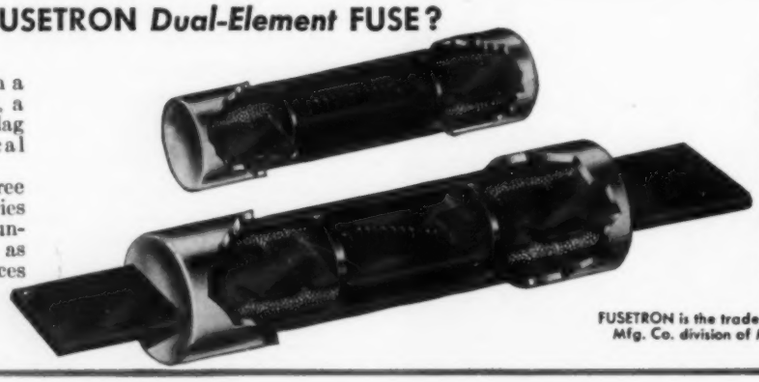
What is the FUSETRON *Dual-Element* FUSE?

A fuse link combined with a thermal cutout—the result, a fuse with tremendous time-lag and much less electrical resistance.

They have the same degree of Underwriters' Laboratories approval for both motor-running and circuit protection as the most expensive devices made.

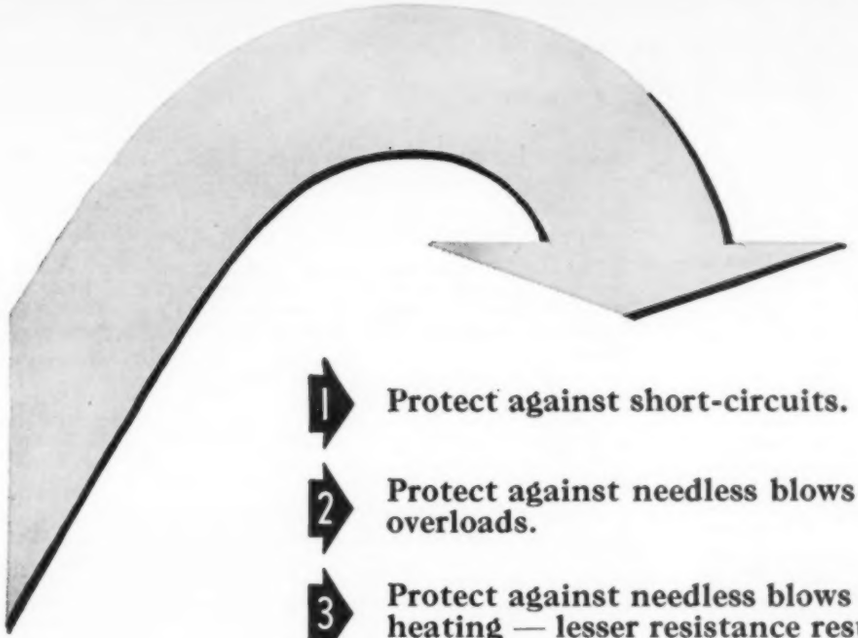


Made to the same dimensions as ordinary fuses — fit all standard fuse holders.

Obtainable in all sizes from 1/10 to 600 ampere, both 250 and 600 volt types. Also in plug types for 125 volt circuits.

Their cost is surprisingly low.

FUSETRON is the trade mark of the Bussmann Mfg. Co. division of McGraw Electric Co.



1. **Protect against short-circuits.**
2. **Protect against needless blows caused by harmless overloads.**
3. **Protect against needless blows caused by excessive heating — lesser resistance results in cooler operation.**
4. **Provide thermal protection — for panels and switches against damage from heating due to poor contact.**
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7. **Give DOUBLE burnout protection to large motors — without extra cost.**
8. **Make protection of small motors simple and inexpensive.**
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FUSETRON DUAL-ELEMENT FUSES *Give ALL-PURPOSE Protection*

One needless shutdown — or one lost motor — or one destroyed switch or panel — may cost you far more than replacing every ordinary fuse with a FUSETRON dual-element fuse.

Don't risk such losses — protect yourself by installing a FUSETRON dual-element fuse in every set of fuse clips throughout the entire electrical system.

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DATE LINE DIARY...

November 1

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 98.9 per cent capacity for the week beginning November 1, 1948. This is equivalent to 1,782,600 tons of steel ingots and castings which is the same as one week ago.

▲ The American Smelting and Refining Company and the St. Joseph Lead Company advanced the price of lead 2 cents a pound to a new all time record high of 21½ cents a pound.

November 2

▲ Production of steel ingots in United States Steel's Pittsburgh district mills of Carnegie-Illinois Steel Corporation reached a new all time high of 974, 561 net tons in the Pittsburgh-Youngstown area, and 270,193 net tons for the National Tube Mills at McKeesport, Pennsylvania and Lorain, Ohio. National Tube Company also set a new blooming mill all time high of 270,193 net tons. The Carnegie-Illinois plants at Gary and South Chicago also set new postwar records of 491,364 tons produced at the Gary Works and 368,286 tons produced at the South Chicago Works.

▲ The Allis-Chalmers Manufacturing Company announced net earnings for the third quarter of 1948 of $3,562,854, which after preferred dividend requirements are equivalent to $1.30 per share of common stock. Unfilled orders on September 30th amounted to $165,506,027 and billings for the third quarter were $78,998,158.

November 4

▲ The Youngstown Sheet and Tube Company reported a net profit of $7,306,000 for 1948.

▲ Walter E. Dudley, a former lumber man demonstrated a new method of making steel at St. Johns, Quebec. In the demonstration iron ore mixed with coke was pressed into briquets and fed into a continuously operated furnace from which molten metal was poured at the end of an hour. The inventor estimates that a plant can be built for a quarter of a million dollars, and that plants could be located at the ore source using wood charcoal. The cost of the method depends on the cost of power.

▲ Domestic freight car deliveries during October totaled 8934 compared to 9753 cars in September.

November 7

▲ Mackintosh-Hemphill Company announced a net profit of $681,831 or $3.73 per common share for the fiscal year ended August 31. Sales of $6,395,181 showed a 60 per cent increase over the previous year's total.

November 8

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 99.4 per cent of capacity for the week beginning November 8, 1948. This is equivalent to 1,791,700 tons of steel ingots and castings compared with 1,782,600 tons one week ago. The scheduled tonnage production will be 400 tons larger than the all time weekly record of 1,791,300 tons in the wartime week of April 24, 1944.

▲ Diamond Alkali Company announced that effective November 1, delivered prices of 100 and 150 pound cylinders of chlorine will be higher.

November 9

▲ The War Assets Administration announced that the government owned Gadsden, Alabama blast furnace has been leased to the Republic Steel Corporation for ten years with options to permit the lease to be renewed up to a maximum of twenty-five years as well as an option to buy. Republic will pay to the government 94 cents per net ton of coke produced in the by-product coke ovens and $1.55 per net ton for basic or merchant pig iron.

▲ The probe initiated by Congress of the lease of the DPC Cleveland blast furnace to the Kaiser-Frazer Corporation has been indefinitely postponed.

▲ The monthly payroll of the iron and steel industry set a new record of $199,440,000 in September. The earnings of hourly, piecework and tonnage workers averaged $1.718. Estimated total employment in the industry was 640,700.

November 11

▲ The United States and British military government officials issued a directive ordering the iron, coal and steel trusts in Western Germany dissolved into separate companies and returned to German ownership. This directive drew strong protests from France.

November 12

▲ The Inland Steel Company announced that effective November 15 the base price on No. 1 Tee rails will be increased from $3.20 to $3.50 per 100 lbs, fob Indiana Harbor, Indiana.

▲ United Nations Economic Commission for Europe stated that some of Europe's steel production capacity will still be idle next year because of lack of scrap iron. The report states that one reason for the shortage is the export of scrap from Germany to the United States. This analysis does not cover the Soviet Union. European steel production was at a rate of 49,500,000 tons a year. Of this amount Germany is now producing 7,000,000 tons a year.

▲ Four companies have announced curtailing operations. Three of these companies laid off employees and the fourth cut its week from five days to four. These firms include the Indian Motocycle Company, Springfield, Massachusetts, Worthington Pump and Machine Corporation, Holyoke, Massachusetts, New York Central Railroad Company, and the L. C. Smith and Corona Typewriter Company, Syracuse, New York.

November 13

▲ F. W. Dodge Corporation estimates that in 1949 there will be a moderate decline in the volume of private residential and non-residential building, and increases in public building and engineering projects.

▲ The price of zinc was increased 2 cents a lb making it 17½ cents a lb. This price is the highest since 1916.

▲ The output of steel ingots and castings in October set a new record figure of 7,973,416 tons which is an average of 99.4 per cent of theoretical capacity.

▲ The Association of American Railroads placed an embargo on practically all freight to Boston and New York for export shipment because of the longshoremens' strike.

▲ The engineers, switchmen and firemens' brotherhoods voted to accept a 10 cent an hour wage increase. The trainmen and conductors of the two other operating unions accepted this proposal previously.

November 15

▲ A large electric equipment manufacturer predicted that generating capacity in the next ten years will increase from 52 to 95 million kilowatts. This should also result in a 50 per cent increase in the electric machinery market.

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 99.0 per cent of the capacity for the week beginning November 15, 1948. This is equivalent to 1,784,500 tons of steel ingots and castings compared with 1,791,700 tons one week ago.

November 16

▲ The Pittsburgh Consolidation Coal Company's gasification pilot plant at Library, Pennsylvania was officially opened. The plant will be used to perfect and commercialize processes already developed in the firm's laboratory.

▲ Workers' claims for about $6,000,000,000,000 in retroactive "Portal-to-portal" pay, were essentially thrown out by the Supreme Court when it refused to review the dismissal by the Federal District Court at Baltimore of the back pay claims of the employees of the B. H. Hubbert & Son Company.

▲ Joseph L. Block, vice president of Inland Steel Company, testified in Washington today that in his judgment although the Inland Steel Company was benefited by the legislation which

made fob pricing mandatory, he was still not favorably inclined toward this selling system.

November 17

▲ A number of steel producers testifying before the sub-committee headed by Senator Capehart asked for legislation which would permit the return to a pricing system which allows freight absorption.

▲ The Lukens Steel Company announced reduction of ½ cent to one cent a lb in base prices of three types of stainless-clad steels.

▲ J. R. Davis, vice president of Ford Motor Company, predicted that cars selling above $2500 will be available for immediate delivery within the next six months. For cars in the Ford price field he predicts a continuation of a sellers market for at least another year.

▲ Kaiser-Frazer announced today that they had entered into a contract with the Phoenix-Apollo Steel Company to purchase the assets of their Phoenixville, Pennsylvania plant. The contract becomes effective December 31, 1948. The purchase price is estimated to be in excess of $3,600,000, and the physical assets include six open hearth furnaces, a blooming mill, and a structural steel mill. Present monthly output is about 26,000 tons of finished and semi-finished steel products. The purchase of this plant will enable K-F to turn substantial amounts of its pig iron supply into semi-finished products for automotive use and eliminate much of the costly bartering.

November 18

▲ Henry Kaiser urged that the incoming Congress establish a tax incentive system to encourage expansion of basic material production. In one suggested scheme, the government would allow an accelerated depreciation period of five years on capital investments for income tax purposes; and another way would be to give tax payers a rebate of ⅓ of the surtax on income which is saved and used to reduce corporation debts or which is put into securities and real estate.

▲ The Ford Motor Company's new blast furnace, the "William Clay Ford" has been completed at the Rouge plant. The new furnace will have a daily production capacity of between 1300 and 1400 tons.

▲ Electric Storage Battery Company announced that it is putting into effect price increases on industrial and automotive batteries ranging between 6 and 9 per cent.

November 19

▲ Westinghouse Electric Corporation denied the Federal Grand Jury charges that it had engaged in monopolistic practices in the sale of street lighting equipment. W. F. White, manager of the Westinghouse Lighting Division, Cleveland, Ohio, said Westinghouse has never knowingly violated any Federal or State law in the sale of its products.

▲ At the hearing made on the Lake Erie and Ohio River Canal conducted by the Army Engineers Board of Review for Rivers and Harbors, a spokesman for the Jones and Laughlin Steel Corporation stated that as a result of their studies the proposed canal would not result in any savings in the cost of transporting its raw materials or finished products; and second, the construction cost appears to be far out of proportion to the probable benefit to the public in general.

▲ Carnegie-Illinois Steel Corporation announced that because of the recent increase of 2 cents per pound in the price of zinc, all galvanized sheet products will be increased about 2 per cent or $2.50 per ton. The National Tube Company decreased base discounts on galvanized pipe by two points, which is equivalent to a price increase on galvanized pipe of $4 per ton or 2.7 per cent. Republic Steel Corporation announced price increases on sheet ranging from $1 to $1.80 per ton. National Supply Company raised its prices on galvanized pipe by $4 per ton. Wheeling Steel Corporation plans to advance prices to cover the increase in the price of zinc.

▲ National Steel Corporation, at its board of directors meeting declared a year-end extra dividend of $1 per share.

November 22

▲ Philip Murray called on the 81st Congress to roll back prices designed to eliminate the seed germ of the next depression. He also proposed an undistributed profits tax, a minimum wage of $1 an hour and federal support of farm prices.

▲ Last week the House of Commons approved a second reading of the steel nationalization bill, 373 to 211. One of the big arguments that labor ministers have is that private industry will not expand because of fear of endangering profits when a slump occurs.

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 99.2 per cent of capacity for the week beginning November 22. This is equivalent to 1,788,100 tons of steel ingots and castings compared to 1,784,500 tons one week ago.

November 24

▲ American Institute of Steel Construction reports that bookings of fabricated structural steel for the month of October declined about 11 per cent from the previous month and were 22 per cent greater than the same month of the previous year.

▲ Steel production in the American Military Zone rose in October to 610,300 metric tons, which is a gain of 7 per cent over the previous month. Pig iron production rose 8 per cent to 508,000 metric tons.

▲ Production of pig iron in October set a new monthly record of 5,459,000 net tons according to American Iron and Steel Institute. This helped make possible the record output of raw steel. Including ferromanganese and spiegeleisen, blast furnace output was 5,520,400 tons. Furnaces were operated at 96.6 per cent of capacity.

▲ Living costs experienced their first decline since last March according to the Board of Labor Statistics. Its index of prices paid by consumers dropped to 173.6 per cent of the 1935-39 average from the record high of 174.5 per cent on August 15 and September 15, 1948. The decrease was due primarily to substantial declines in food costs.

November 26

▲ The owners and union officers agreed on terms ending a sixteen day old longshoremen's strike. The agreement includes a 13 cent hourly wage increase as well as other benefits.

▲ Bureau of Mines reported that coal production in 1947 set a new record, and that the production of bituminous-coal and lignite was 630,623,722 tons for 1947. This compares with the wartime record of 620,000,000 tons. Employment in the industry rose from 396,434 to 419,182 men, and production per man increased 1.9 per cent from 6.30 tons a day in 1946 to 6.42 tons a day in 1947.

November 27

▲ According to the American Iron and Steel Institute, alloy steel production in the first ten months of 1948 was nearly 7,000,000 net tons, or 909,000 more tons than for the similar 1947 period. Electric furnace production has been setting monthly records and in ten months the total was nearly 4,077,500 tons or 975,000 tons greater than the previous year. Most of this increase in electric furnace output was in carbon steel. Electric furnace operation in October rose to 101.5 per cent of capacity.

November 29

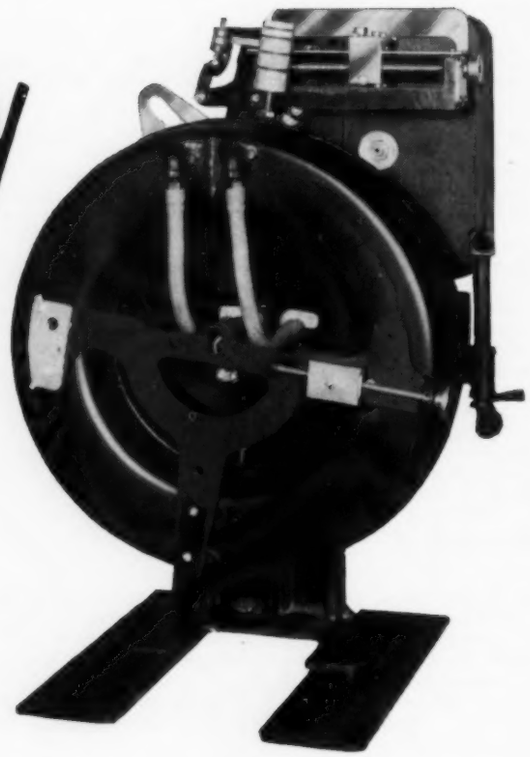
▲ A six month labor dispute which shut down the Midvale Company ended with the granting of a 10 cent hourly increase for most of the production workers.

November 30

▲ The average postwar passenger cars require about 200 lb more steel than late prewar models and up to 1000 lb more than those made in the early thirties.

▲ The operating rate of steel companies having 94 per cent of the steel capacity will be 100.1 per cent capacity for the week beginning November 30, 1948. This is equivalent to 1,804,300 tons or 12,600 tons above the previous all-time peak.

3 reasons why the steel industry likes Hagan Ring Balance Flow Meters



1 • Exceptional sensitivity.

In Hagan Ring Balance meters, operating torque depends on the cross-sectional area of the ring, and the torque resulting from a given differential pressure is made high by using a ring of large area. Since the ring body rotates on a knife-edge bearing, friction is extremely low, giving these meters a high torque-to-friction ratio. Hagan meters can therefore give *full scale operation with differential pressures as low as ½ inch of water.*

2 • Accuracy over a wide range of flows.

Accuracy of the Hagan Ring Balance meter at medium or high flows is at least equal to that of other types, and at low flows it is definitely superior. In Hagan meters the movement of the ring body at low flows must actually be *reduced* by the linkage which transmits the ring movement to the pen. This greater movement of the meter element at the low differential, makes for high accuracy and sensitivity at low flows—a feature which makes the meter especially popular for measuring fuel and air flow to soaking pits.

3 • Easily adjustable range.

Ring torque is resisted by a leaf spring. By means of a simple range screw this resistance may be adjusted for maximum differentials within a range of 7 to 1. Greater changes in differential are obtained by the substitution of a different ring. Thus the same Hagan Ring Balance meter is easily adjusted to meet changed operating conditions, or may be used for an entirely different application than the one for which it was originally selected.

For full information on Hagan Ring Balance Flow Meters, write for Bulletin 2M48. Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

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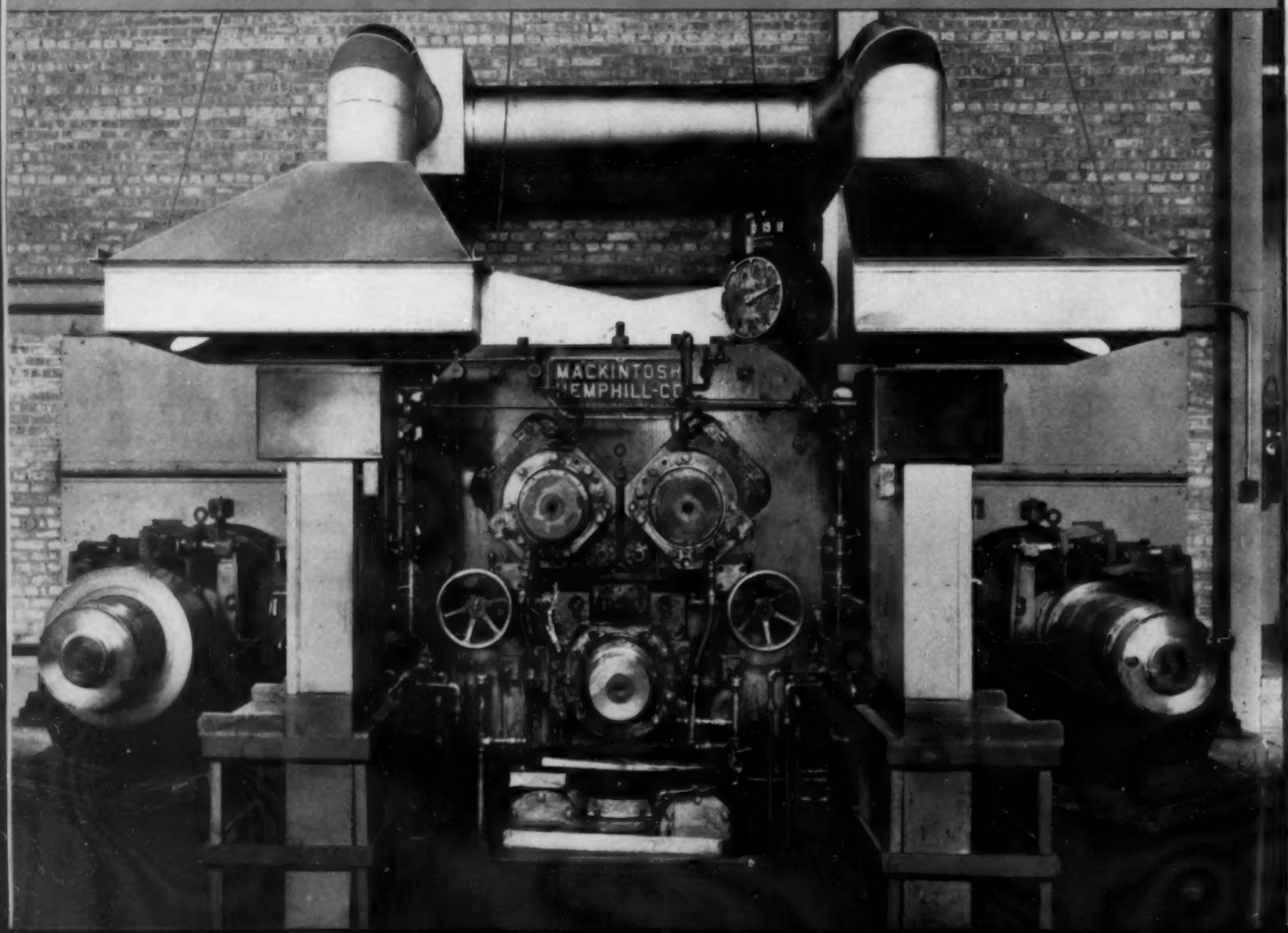
Mackintosh-Hemphill Y-Mill, a 7-Roll reversing cold strip mill utilizing small-diameter work rolls.



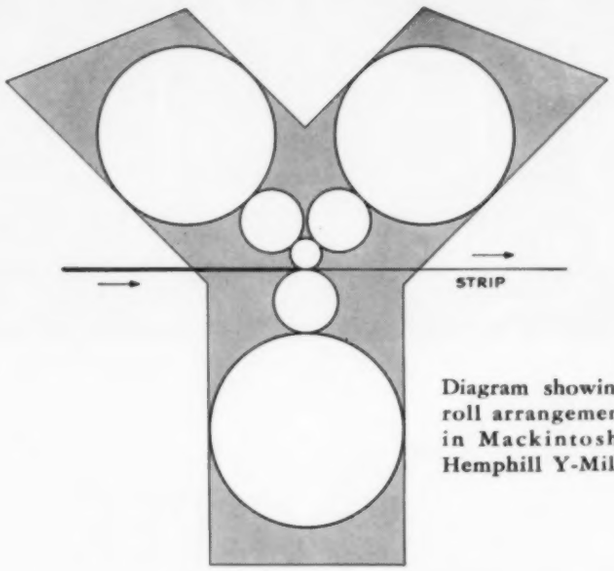


Diagram showing roll arrangement in Mackintosh-Hemphill Y-Mill.

Designed for high-speed rolling of all grades of steel, the Mackintosh-Hemphill 7-Roll reversing cold strip mill employs small-diameter work rolls for reducing hot-rolled strip to commercial cold-rolled gauges.

The Y-type arrangement of the rolls in a compact, rigid housing results in increased penetration ability over a 4-high mill, with equivalent surface finish and greater accuracy of gauge.

Characteristics of the Mackintosh-Hemphill Y-Mill include—

- Low Separating Force Between Work Rolls
- Long Roll Life
- Operates at 1200 Feet Per Minute On Finish Passes

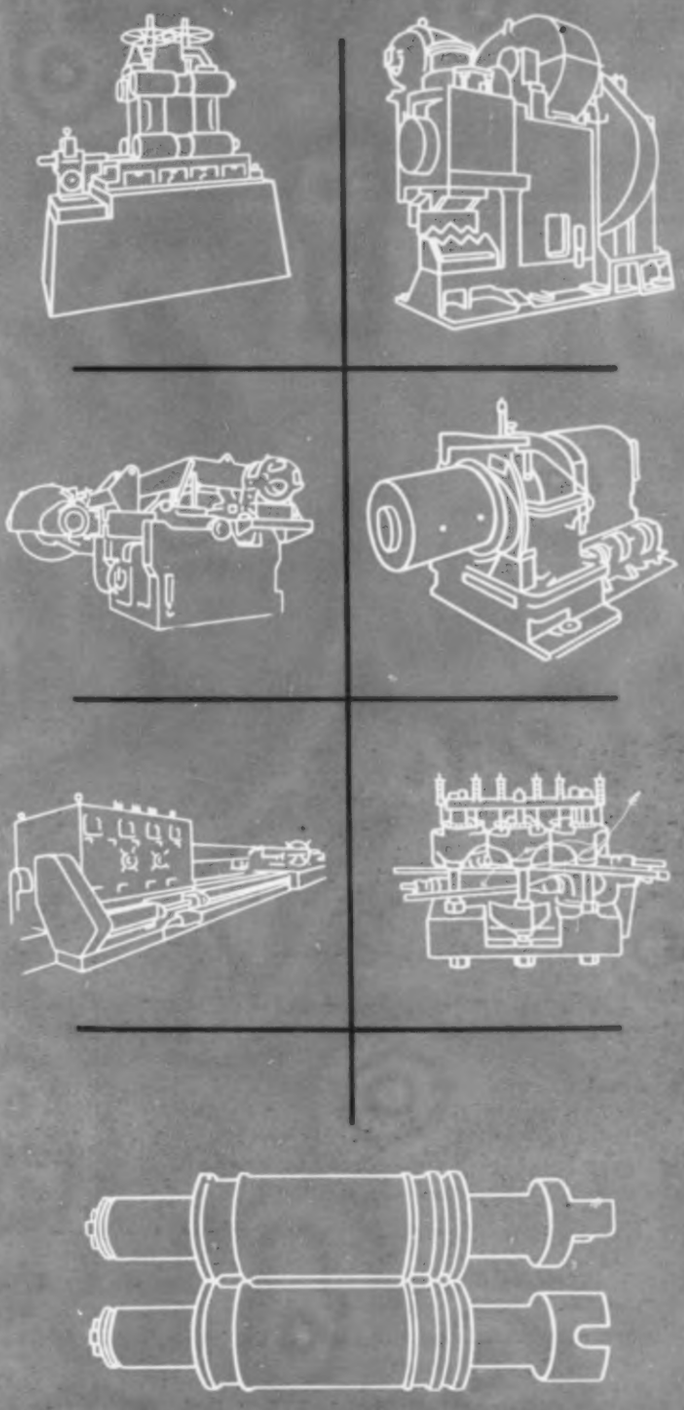
This modern mill for modern metals can be used in rolling all grades of steel and non-ferrous strip, and is particularly effective in reducing the higher-carbon steels. In actual operation the Mackintosh-Hemphill Y-Mill has demonstrated these advantages—

- High Productive Capacity on Hard Metals
- Elimination of Intermediate Anneals
- Uniformity of Product Rolled
- Simplicity of Adjustment and Operation

If you process commercial tonnages of strip, or plan to increase your rolling capacity, there's a place in your productioneering program for a Mack-Hemp Reversing Cold Strip Mill; Mackintosh-Hemphill engineers will show you how well the Y-Mill fits your requirements.

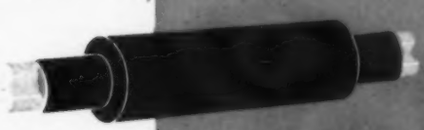
And when you buy Mack-Hemp Rolling-Mill Machinery you can expect superior performance. For more than a century Mack-Hemp equipment has been tested and accepted wherever operators demanded exceptional metal-rolling results. In your planning for expansion or modernization it will pay you to keep your eye on what's new at Mack-Hemp.

Some of the widely diversified types of production machinery manufactured by Mackintosh-Hemphill for the metals industry.



MACKINTOSH-HEMPHILL CO.

Makers of the Rolls with the Red Wabblers



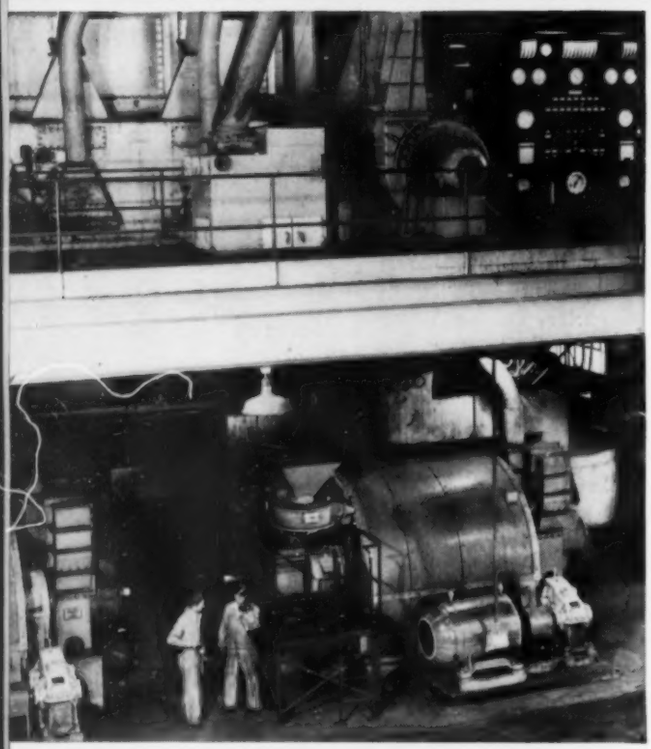
PITTSBURGH AND MIDLAND, PA.

Other Mackintosh-Hemphill products include:

ROLLS . . . STEEL AND SPECIAL ALLOY CASTINGS . . HOT STRIP MILLS . . . HEAVY DUTY ENGINE LATHES . . . THE NEW MACKINTOSH-ABRAMSEN STRAIGHTENERS . . . IMPROVED JOHNSTON PATENTED CORRUGATED CINDER POTS AND SLAG HANDLING EQUIPMENT . . . SHAPE STRAIGHTENERS . . . SHEARS . . . LEVELERS

DOWELL

SPECIALISTS IN SCALE AND SLUDGE REMOVAL WITH CHEMICALS



How much POWER can Dowell Chemical Scale Removal Service Restore for you?

Power engineers have found in Dowell's *chemical* scale removal service a modern method for *restoring power*. They know that more efficient operation of boilers, condensers and other heat exchange equipment has been achieved after removal of the insulating scale and sludge deposits by this tested service. They have seen for themselves how effective Dowell's service really is.

Dowell engineers treat your equipment with liquid solvents designed to dissolve and disintegrate the accumulated deposits which retard heat transfer. They are experienced in practical methods, know which solvents to use, and bring with them special truck-mounted tanks, pumps, mixers, heaters and control equipment.

Dismantling and down time are held to a minimum in Chemical Scale Removal Service. The solvents are pumped into the equipment through the regular connections. The most complicated heat transfer equipment has been cleaned effectively by Dowell solvents which reach wherever steam and water flow.

Call or write the office nearest you for a free estimate of the cost of cleaning your boilers, condensers, heat exchange equipment, water lines—and for increasing water well output.

DOWELL INCORPORATED · TULSA 3, OKLAHOMA

SUBSIDIARY OF THE DOW CHEMICAL COMPANY

CALL

New York 20	Buffalo 2	Kansas City 8	Mt. Pleasant, Mich.
Boston 16	Cleveland 13	Wichita 2	Hamilton, Ohio
Philadelphia 2	Pittsburgh	Oklahoma City 2	Charleston 27, W. Va.
Baltimore 18	Detroit 2	Houston 2	Salem, Illinois
Wilmington 99	Chicago 2	New Orleans 12	Borger, Texas
Richmond 19	St. Louis 8	Ft. Worth 2	Midland, Texas
Jacksonville	Indianapolis	Shreveport 23	Wichita Falls, Texas
Atlanta	Louisville	Anniston, Ala.	Lafayette, La.

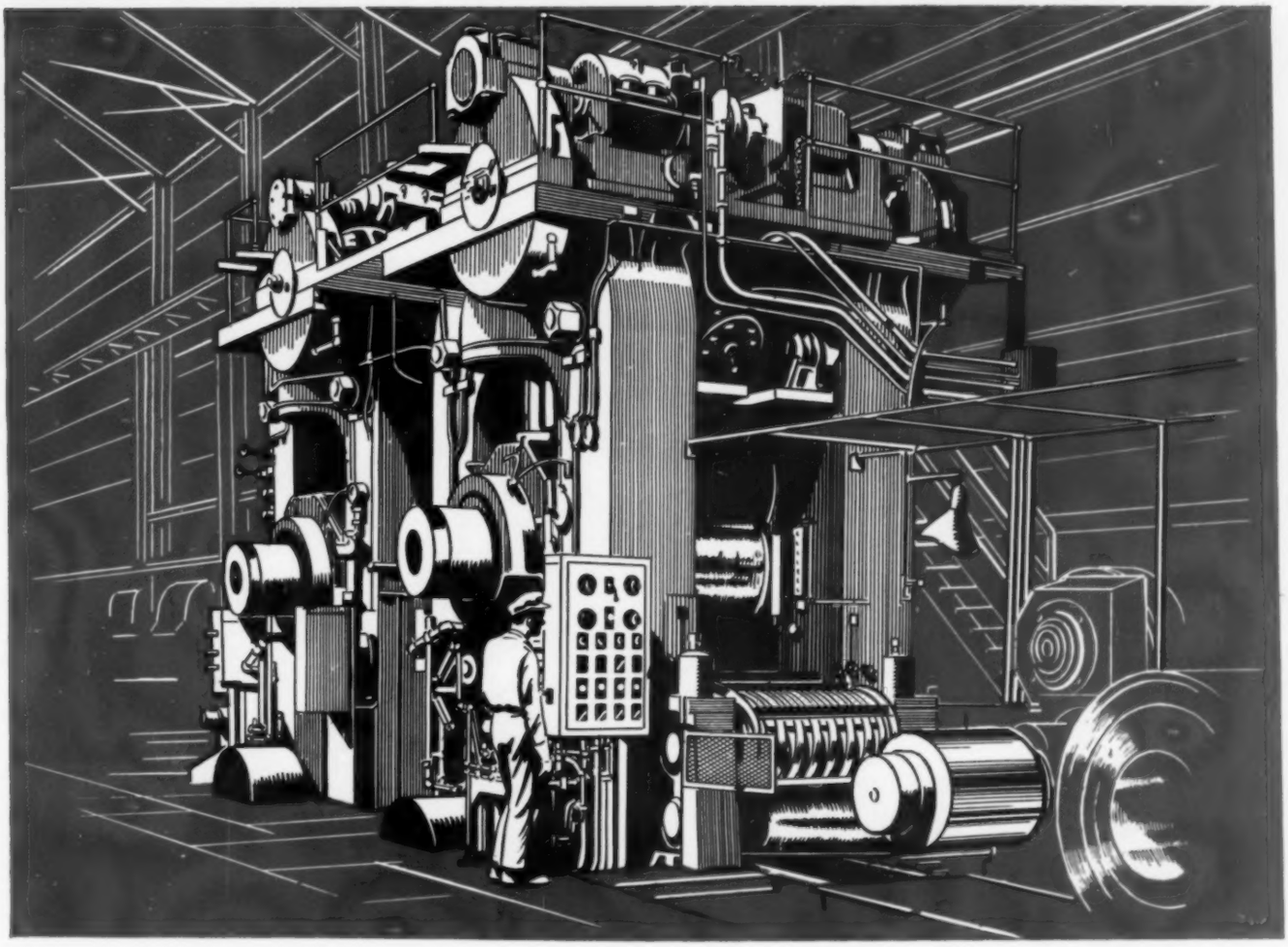
Long Beach, Oakland, Casper: Dowell Associate—International Cementers, Inc.

DOWELL

A SERVICE ORGANIZATION

YES! Tycol Apreslube Lubricants

perform better . . . BETTER . . . BETTER



Tycol Apreslube Lubricants perform better because:

. . . *Tycol Apreslubes* are extreme pressure lubricants that stand up under severe heat and moisture conditions, under tremendous loads.

. . . *Tycol Apreslubes* are highly stable, will not separate while in storage or service. They inhibit against corrosion even in presence of water.

. . . *Tycol Apreslubes* mean lower lubrication costs . . . longer service life for your equipment.

. . . *Tycol Apreslubes* never thin unduly at high temperatures. They guard against overheating and excessive wear in gears and bearings.

Your nearest Tide Water Associated Office is ready to help you select that Tycol Apreslube lubricant best suited for your particular need. Call or write today.

TYCOL

INDUSTRIAL LUBRICANTS

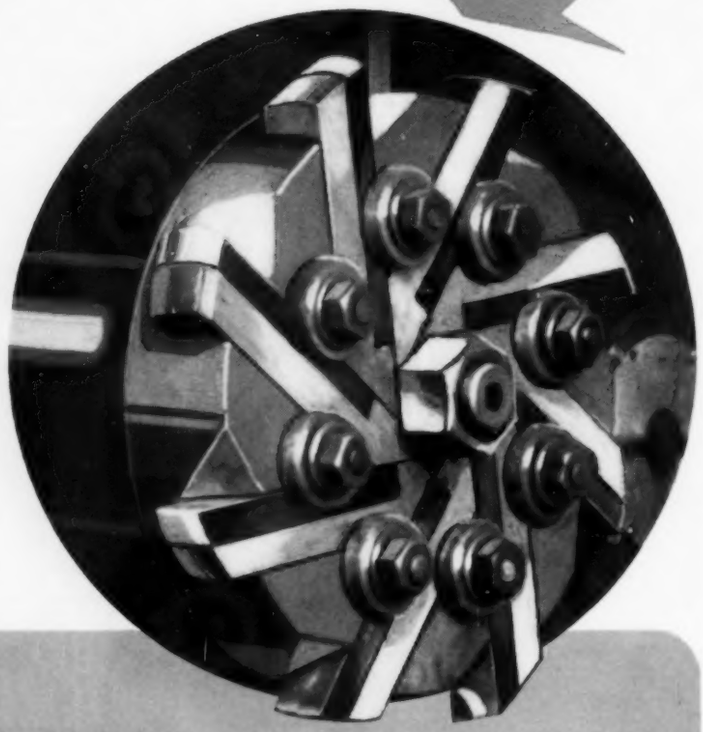
Boston • Charlotte, N. C.
Pittsburgh • Philadelphia
Chicago • Detroit • Tulsa
Cleveland • San Francisco

TIDE WATER ASSOCIATED OIL COMPANY

17 BATTERY PLACE · NEW YORK 4, N.Y.

LUBRICATION — "ENGINEERED TO FIT THE JOB"

As the alloy-steel teeth of the cutting head of the Bonnot Billeteer "bite" into bad billets, they also *"bite" into billet-conditioning costs as deeply as 56%.* Such savings are conclusively proven in cost studies covering the reconditioning of 25,000 tons of billets.



And here are other savings from Billeteer operation—features not available in any other billet conditioning method:

Saves

REMELTING of billets—normally not salvageable—by biting out all defects, even those inches in depth. Inventory of billets can therefore be reduced to a minimum.

Saves

PRODUCTION SCHEDULES because the Billeteer works dependably, shift after shift, day after day—some units with service records of 80,000—90,000—100,000 hours each.

Saves

SCRAP—tons of clean chips of known analysis each day ready for remelt usage.

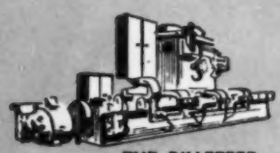
Saves

WORKER EFFICIENCY—the 45-ton machine responds — instantly and smoothly—to finger-tip control, reducing fatigue, illness, accidents and physical drag which result from worker exhaustion in "more muscular methods"

Write today for full information.

Engineered for Improved Production

The Bonnot Co.
STEEL EQUIPMENT DIVISION
CANTON 2, OHIO



THE BILLETEER

ALSO MANUFACTURERS OF SAWING · CRUSHING · PULVERIZING & MIXING EQUIPMENT

First there were 2 Bliss Cluster Mills NOW THERE ARE 10

Small Bliss Cluster Mills, reversing and one-way, have proved their year-in, year-out efficiency in cold reducing narrow high-carbon and stainless steel. That's why one company has added a new battery of eight Bliss mills to the two originally installed.

Here are some of the operating features that make these rolling mills so practical:

Mills are easy to install, being mounted on one-piece base. Rolls are easy to change. Maintenance is low.

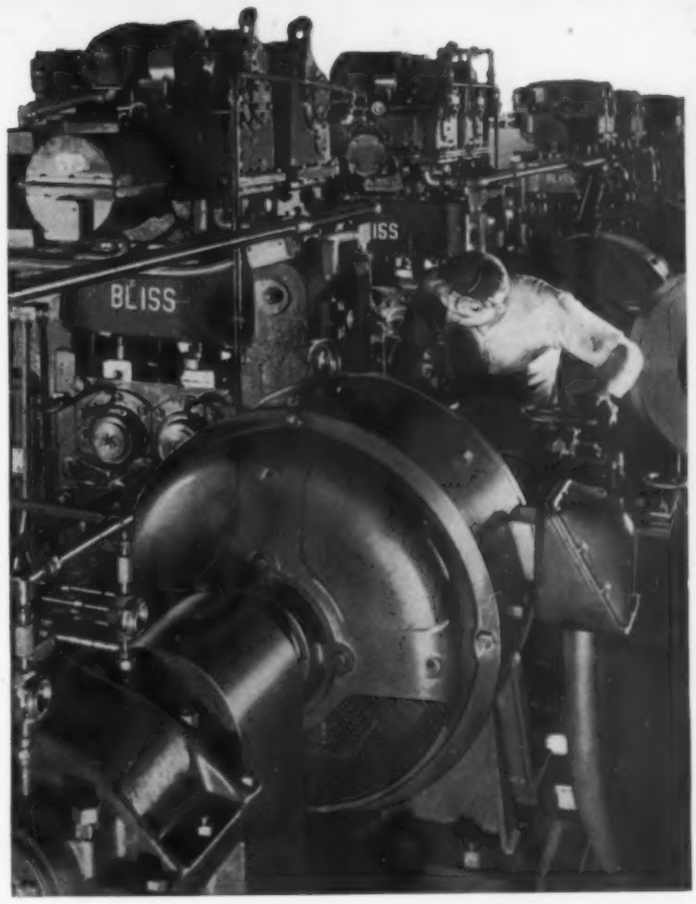
Motor control of screw-down gives better control of gage. Stalled tension is maintained when necessary.

Lubrication is automatic... mill stops if oil or grease pressure fails.

Moving parts are completely enclosed wherever possible for safety.

These sum up to the kind of skill that's built into all Bliss equipment... the related know-how that comes of merging ninety years of experience into rolling mill engineering and construction.

It may be just what you need to solve your rolling mill problem. Talk it over with a Bliss Sales Engineer.



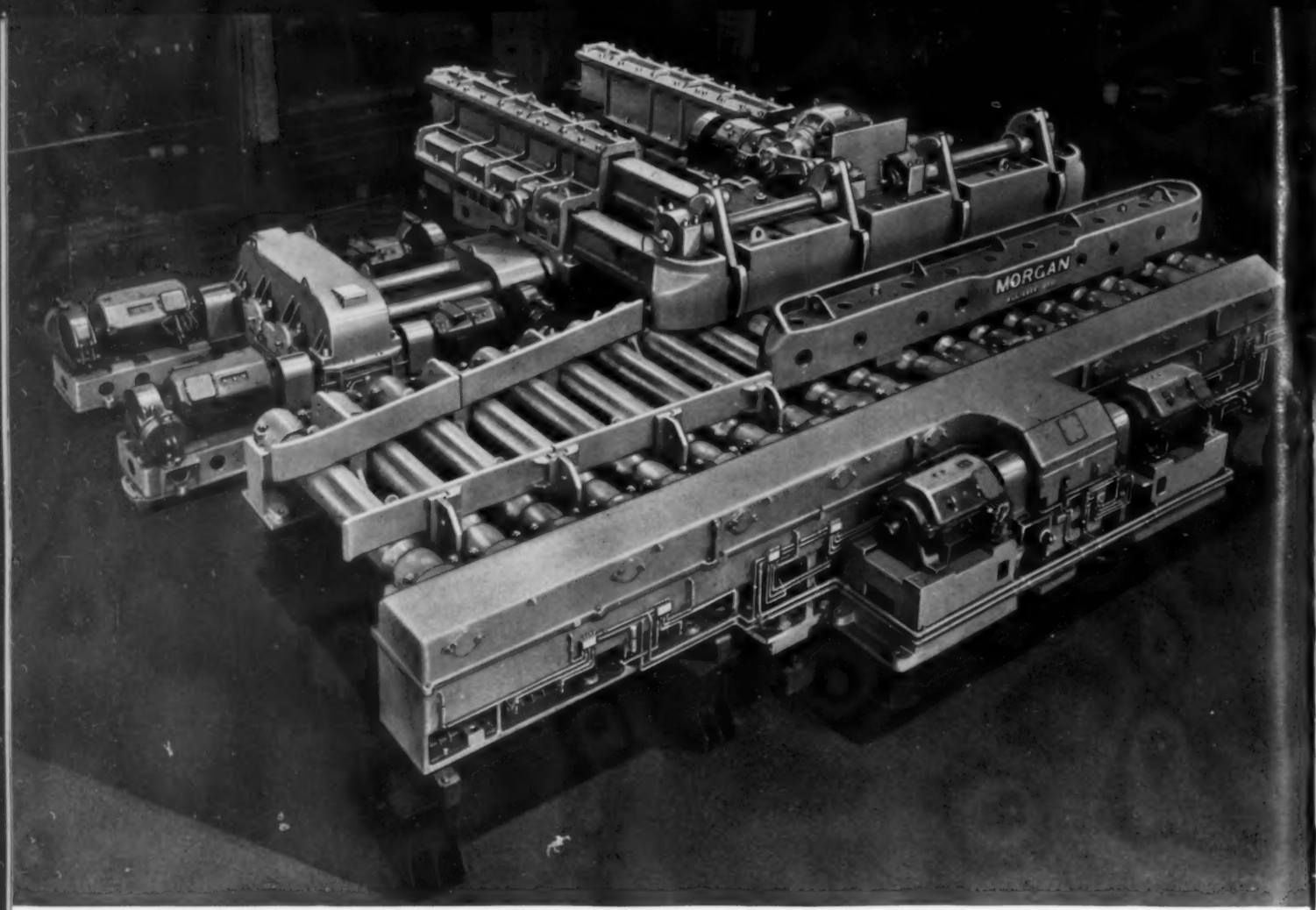
Bliss Cluster Mills shown have 3¼" dia. work rolls, 9" diameter backing rolls and 8" face width. Electrically controlled tension reel is adjustable from 1100# to 150#.

Cold reducing high carbon alloy and stainless steels from gages of .125" to .004". Delivery speed ranges 100 to 400 fpm with suitable variable speed motor.

Quick loading and reloading of coils keep Bliss mills producing with little interruption. Operator is readying new reel as stock in mill nears end of finish-rolling.

E. W. BLISS COMPANY, DETROIT 2, MICHIGAN

Manufacturers of two-, three-, and four-high mills for hot and cold rolling; single stand, reversing, or tandem mills for ferrous or nonferrous metals. Accessory mill equipment furnished complete.



45″ BLOOMING MILL TABLE AND MANIPULATOR

Morgan 45″ Blooming Mill Manipulator with Front Mill Table. Manipulator is of the overhead type, electrically driven, with retractable heads so the table rollers can be removed without dismantling the manipulator heads. Table girders are of cast steel box section type with integral oil trough on drive side. All gears are totally enclosed, operating in oil, and have hardened teeth. All bearings are of the anti-friction type lubricated through a centralized motor operated system.

BUILT BY MORGAN Engineering

THE MORGAN ENGINEERING CO.
ALLIANCE, OHIO PITTSBURGH—1420 OLIVER BUILDING

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

NEWS SUPPLEMENT DECEMBER, 1948

Equipment
Personnel
Literature

Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

MESTA MACHINE COMPANY CELEBRATES GOLDEN ANNIVERSARY

▲ November 21, 1948 marked the fiftieth anniversary of the founding of the Mesta Machine Company. However, the name Mesta was already well known throughout the steel industry in 1898; in fact, the chain of events which resulted in the incorporation had its beginning eleven years earlier.

In 1885 George Mesta graduated from the Western University of Pennsylvania, now the University of Pittsburgh. For a time he taught mechanical drawing but saw a broader opportunity for his inventive talents in industry and in 1887 accepted a position as director of the engineering department of the Leechburg Foundry and Machine Company, located at West Leechburg, Pennsylvania.

It was not long before George Mesta demonstrated his inventive ability, and in 1892 he was awarded a patent on a machine for removing scale from steel. This product is still known as the Mesta patented pickling machine and is universally used throughout the steel industry.

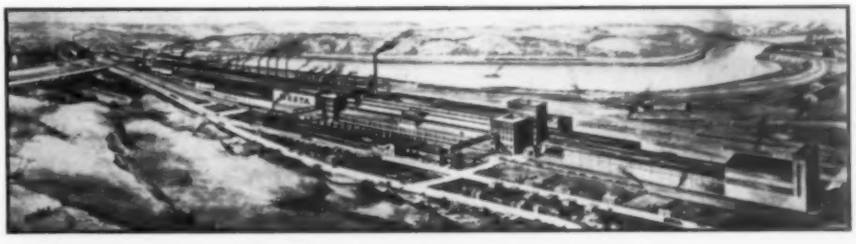
Financial assistance from his family and friends enabled him to purchase a controlling interest in the Leechburg company, and under his aggressive leadership, as president, the small concern soon outgrew its limited facilities. The chief competitor in the manufacture of heavy steel mill machinery at that time was the Robinson-Rea Manufacturing Company of Pittsburgh. George Mesta foresaw the favorable future possibilities that would follow the consolidation of these two companies and worked diligently to accomplish this end.

In 1898 the merger was completed; the Mesta Machine Company was born and George Mesta was elected president. A large tract of land was purchased in the borough of West Homestead, in the center of the Pittsburgh area's fast growing steel industry. Complete and integrated manufacturing facilities, consisting of plant and office buildings, were erected on the new site. The location of the plant gives it unsurpassed shipping facilities. It has direct connection with three of the nation's largest railroad trunk lines.

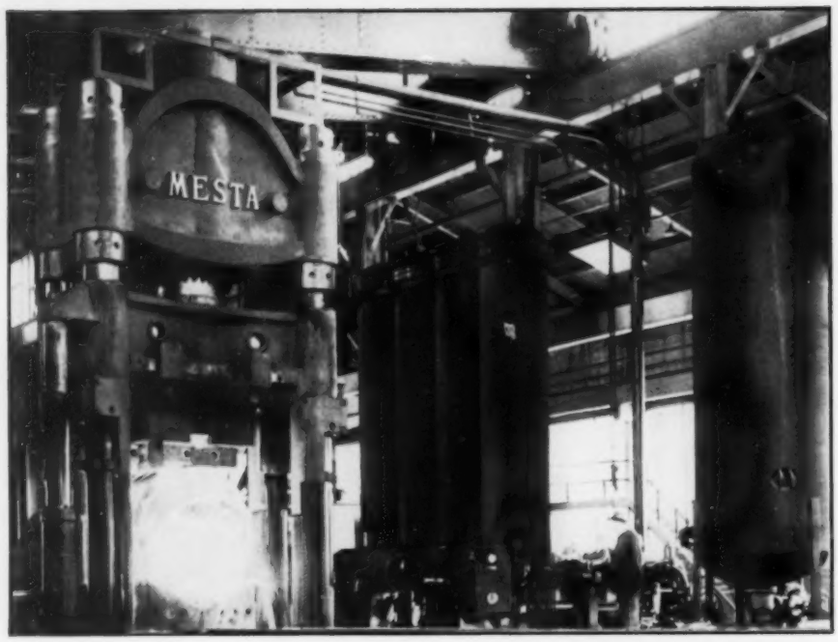
The new company was favored with an ever increasing volume of business and its growth has paralleled that of the great American industries which it serves. Mesta has made many important contributions in the field of design and invention, and has become famous in this country and abroad as the leading manufacturer of steel plant equipment, rolls, and heavy duty machinery.

A large and capable engineering department is maintained where the machinery built by the company is designed. Plans for complete plant projects are also developed. These include not only designs for mechanical equipment, but also for buildings, foundations, electrical distribution systems, and all engineering required for the creation of a modern industrial plant.

A staff of practical and experienced construction supervisors is constantly employed in the field to see that the detailed plans of the engineering de-



Participating in the celebration of Mesta's fiftieth anniversary were (above): J. R. Berg, vice president; F. A. Mesta, vice president and treasurer; Lorenz Iversen, president, and L. W. Mesta, executive vice president. Below, the general offices and works of Mesta at West Homestead, Pennsylvania, in 1948.



A large ingot is being forged on a 6000 ton hydraulic press built by the fifty-year old firm.

partment are efficiently executed. They direct the work of building erection and equipment installation, from breaking ground to completion.

President Lorenz Iversen exercises direct supervision over all operations of the company. In the years since he started with Mesta as a young man in the drafting room, Lorenz Iversen has gained world-wide recognition as an outstanding engineer and designer of many of the important machines used in industry today. Under his capable leadership as President since 1930, the company has continued to maintain and strengthen its pre-eminent position.

40,000 GUESTS VIEW ALLEGHENY LUDLUM

▲ Almost 40,000 persons were guests of Allegheny Ludlum Steel Corporation as residents of plant communities and some 200 customer companies joined the management and employees of plants at Dunkirk, New York, and West Leechburg, Pennsylvania, in staging simultaneous open house programs and anniversary celebrations. More than 22,000 persons registered while visiting the Dunkirk plant on October 19 and 20, and hundreds went through without signing registration cards. Approximately 15,000 registered at the West Leechburg open house, a majority of them on October 20, the previous day having been set aside exclusively for employees and their families. Since the visitors represented crowds more than twice the total population of the communities, the programs were considered highly successful, proving the value of several open house techniques attempted for the first time.

Stockholder booths were installed at the entrance of both tours and armbands were pinned on the stockholders as they entered. Aside from the armband, no special attention was given them.

1949 ELECTRICAL BUYING TO EXCEED 1948 HIGH

▲ Purchases of electric motors, generators, adjustable-speed drives, and controls by the nation's key industries in 1949 to drive their production machines and power their processing lines will match, and may well exceed, today's high buying level.

That is the concensus of 58 district managers and field sales engineers from 27 cities across the country of one major manufacturer of electrical equipment, The Reliance Electric and Engineering Company of Cleveland and Ashtabula, Ohio.

Plant expansion projects and equipment modernization programs which many producers of industrial goods and consumer products have either on the drawing board or in the blueprint stage, installation of additional generating capacity by electric utility companies to meet long-range power requirements, and increased mechanization of operations to offset rising production costs were cited in the survey as three of the principal bases of expectations that electrical equipment purchases by industrial consumers would continue at a brisk pace next year.

Other important factors entering into present and prospective purchases of new motor-driven machinery by various industrial plants also were specifically mentioned. These include, among others, the increasingly discernible intensification of efforts by more and more manufacturers to effect closer control of product quality, achieve greater uniformity in processing, increase productivity and reduce unit costs wherever practicable.

DONORA BLAST FURNACE IS BEING RELINED

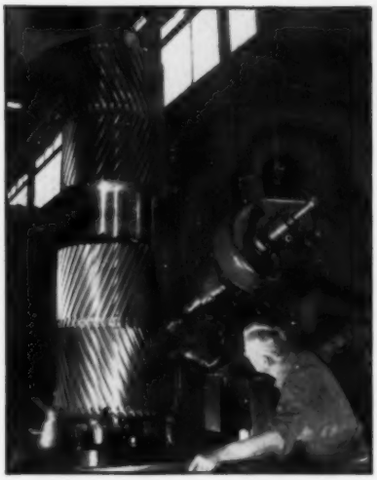
▲ No. 1 blast furnace at the Donora, Pennsylvania, steel and wire works of American Steel and Wire Company, U. S. Steel subsidiary, has been blown out for relining after producing 2,003,500 net tons of pig iron. Blown in on January 18, 1941, the furnace has been in continuous operation for seven years and nine months, with an average daily production approximating 700 net tons. The rated capacity is 600 net tons per day.

Estimates range from 60 to 65 days to complete the relining project. The A. E. Anderson Construction Company of Buffalo has the relining contract, while the American Bridge Company will do the structural work.

GEAR STEEL OUTLASTS UNTREATED GEARING

▲ Steel mill service usually means continuous duty and heavy shock loads. Therefore, the advantages of heat-treated gearing for many steel mill applications such as mill pinions, track wheels, cranes, hoists, car dumpers, etc., are multifold. Experience over the past forty years has shown that Westinghouse "BP" gear steel will outlast untreated gearing four to five times. This means lower maintenance costs and increased production schedules.

Gearing made of this material,



The advantages for steel mill applications are multifold.

which is not a premium product, has the unique features of a high surface hardness and a tough ductile core that is amazingly shock resistant. This is accomplished by a gradual decrease in hardness from surface to the center of the tooth which is accompanied by increased ductility and toughness.

This gear steel is available for all types of gearing — spur, helical and herringbone and in sizes as large as 120-in. pitch diameter, 48-in. face.

MAKE PROGRESS IN BOTTOM REFRACTORIES

▲Considerable progress has been made in the manufacture of bottom refractories that resist slaking during long periods of shutdown and show improvement of bonding qualities and notable freedom from disintegration and hydration.

Indication of the extent of this progress is contained in the results of a recent survey completed by research engineers of Basic Refractories, Inc., at the DPC armor plant of the General Steel Casting Company, of Madison, Illinois.

The company's open hearth facilities, consisting of five 60-ton furnaces, were in the process of being removed to Niles, California for re-erection.

According to W. C. Knoblaugh and J. B. Jeanette, who completed the tests, these furnaces were installed in 1942. Three never had a heat of steel made in them. The company's 0.1 furnace ran 186 heats and its 0.3 furnace ran 106 heats.

The bottoms of all five consisted of approximately 12 inches of "Ramset" surfaced with "Basifrit" and mixed with five per cent of slag. A rabble had never been used on these bottoms, according to the plant superintendent.

During the dismantling process, arrangements were made to cut through the bottoms to obtain cut-out samples for laboratory tests and inspection.

The walls of the 0.1 furnace (after 186 heats) were removed first during the dismantling and the bottom was cut through at one end. The debris was removed to the last course, to brick covering the pan. The cross-section of this view is

A cross-section of the bottom of the No. 1 furnace. Starting at the pan, this bottom consisted of two courses of chrome brick, 12 in. of "Ramset" and about 4 in. of "Basifrit."

HAYS CAN SHOW YOU HOW...

INSTRUMENTS AND CONTROLS FOR EVERY NEED

TO IMPROVE PRACTICALLY ANY PHASE OF STEEL PROCESSING, TO CUT FUEL AND LABOR COSTS

The bulletin illustrated is not just a piece of sales literature but a complete 24 page treatise on the instrumentation and automatic control of steel making and heat treating furnaces. You'll want a copy for your reference files, want to profit from its practical, authoritative information.

And remember as you read it, Hays engineers are thoroughly qualified and ready to work hand-in-hand with you in solving your own specific instrumentation and control problems . . . without obligation.

Write for your copy today . . . Ask for Bulletin No. 48-750 (covering heat-treating furnaces). Companion edition covering open-hearth furnaces will also be included.

Steel that's better, with more uniform grain structure . . . maximum production because of continuous equipment performance . . . fewer rejects . . . lower fuel, maintenance and labor costs—these are advantages you can count on when you use Hays instruments and controls for:

Annealing
Brazing
Colorizing
Carburizing
Cyaniding
Enameling
Glazing
Hardening
Heating
Heat treating
Melting
Nitriting
Normalizing
Tempering
Welding

For indicating and controlling:
Pressure
Flow
Furnace Draft
Fuel air-ratio
Gas analysis

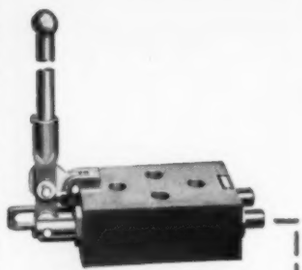
Inquiries invited on any of these specific applications.

The HAYS CORPORATION
Since 1901
COMBUSTION & INDUSTRIAL INSTRUMENTS & CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

For a maximum of long, efficient, trouble-free service

● Quick-As-Wink Valves are high quality controls designed and built to meet the most exacting requirements. All operating parts are in pressure balance eliminating any tendency to creep or crawl. The U-shaped packers are expanded by pressure and seal tightly preventing leakage. There is no lapping—no grinding—no metal-to-metal seating. Every valve is precision made and individually tested to its full pressure rating before being shipped.

Furnished in hand, foot, pilot, solenoid and diaphragm operated designs for controlling all types of air and hydraulic equipment. Let us work with you on your requirements!



Quick-As-Wink Lever Operated Hydraulic Valves

The HS-551-N4 pictured above is a neutral position 4-way valve for controlling double acting cylinders. It has a machined steel housing, chrome plated and polished stainless steel plungers, and renewable metal rings to take the impingement of the liquid flow preventing wear on the U-packers. Used for oil or water up to 3500 P.S.I. and 150° F. Other valves available for pressures up to 5000 P.S.I.;—but send for a catalog today and get *full* details about the *complete* line.

Quick-As-Wink Control Valves

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Manufactured by **C. B. HUNT & SON, Inc.,** *Salem, Ohio.*

Engineering and Sales Representatives in the Principal Cities

illustrated on about the longitudinal center line of the furnace. The slight disintegration of the working surface was caused by wetting the furnace down during the wrecking, to reduce the dust.

BATH PYROMETER USES PHOTO-ELECTRONIC CELL

▲ A photo-electronic bath pyrometer for high speed and accurate measuring of molten steel temperature at greatly reduced production and replacement costs has been developed by Brown Instrument Company in cooperation with metallurgical engineers.

For a number of years one of the leading steel companies, working within its own organization to modify and perfect the purge-tubed method of measuring steel bath temperatures, designed a rugged air-purged immersion tube having a photo-electric cell mounted at its rear end.

The output from such a cell, when calibrated in terms of temperature, is approximately a 12th-power function of absolute temperature, providing an extremely open scale at normal operating temperatures.

About three years ago an electronic indicating and recording pyrometer, with special modifications, was developed for use with this measuring unit, thus greatly simplifying the previously used measuring instrument. In addition, this measuring circuit design provided excellent stability to the calibration characteristics of the measuring cell.

The amplifying unit and 24-hour chart drive circuit are continuously energized, giving immediate response to temperature indication, when the pushbutton on the purged sighting tube is depressed, and continuous indication of last temperature reading plus the exact time the temperature was taken.

Using compressed air for purging, the instrument reading for open hearth steels, in the range of 2900 to 3050 F, is established to correspond to the usual plant practice in measuring tapping temperatures with an optical pyrometer using an emittance value of 0.40. This calibration also permits a check on the operating floor by reading back wall temperatures with the purged sighting tube, and comparing with optical readings set for blackbody conditions.

Recent studies indicate that molten

Specify— PYLE-NATIONAL FLOODLIGHTS

for Permanent Heavy-Duty Floodlighting

10"-12"-14"-16"-18"-23"
for 100 to 2000 watt lamps

Dependable Floodlighting with Minimum Maintenance

PORTABLE
10"-12"-14"-16"
100 to 1000 watts

FLUSH—10" for Pit or Subway Wall or Ceiling
100-150-200 watts

SHORT RANGE—10"-12"
for Wall Mounting
100-150-200 watts

Pyle-National floodlight equipment is designed and constructed to withstand the most severe operating conditions. Complete range of types and sizes are available.

RUGGED cast aluminum housings with tight sealing doors and door glass joints—positively dust proof and moisture proof—give maximum protection to reflectors and lamps and reduce cleaning and other maintenance to an absolute minimum.

STRONG, galvanized cast iron bases and brackets of many types are provided for simple mounting and accurate adjustment in all locations.

ADVANCED DESIGN of the carefully molded and highly polished reflectors and lenses insure the highest optical efficiency—thoroughly annealed for maximum toughness.

Write for catalog 2100 giving complete information.

The services of our trained and experienced floodlighting specialists are available at all times to advise and assist in installation problems.

SINCE 1897

THE PYLE-NATIONAL COMPANY

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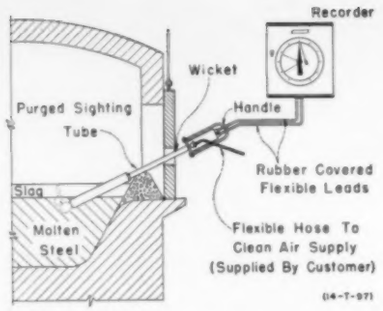
steel in air has an emittance of about 0.50 at 3000 rather than the commonly used value of 0.40. Thus the usual optical readings made during tapping on the basis of 0.40 are from 40 to 60 higher than actual bath temperatures in the usual tapping range. When air is used for purging the inner surface of the steel cavity, formed by the air pressure, it is believed to be oxidized by the air, causing a higher than actual steel temperature reading. Where absolute temperature measurements are to be made, the tube can be purged with an inert gas such as nitrogen or the instrument can be calibrated to true bath temperature values.

The sighting tube is approximately 7 ft long, sufficient to permit the required immersion in the open-hearth bath even if the doors are highly banked. The tube which weighs 75 lb consists of a 2-in. standard pipe-size outer tube, screwed into a 2⅞-in. outside diameter sleeve of cold drawn steel, with an air cooled 1⅞-in. outside diameter seamless inner tube inside the full length.

A low carbon steel cap with a 0.6875-in. orifice is located at the immersion end of the tube, a light sensitive cell of the photo voltaic type in the other, and interposed between are eight sight-limiting diaphragms which intercept all stray reflections from the inner surface of the inner tube.



The sighting tube is 7 ft long, sufficient to permit the required immersion.

A clear glass window located in front of the photo cell protects the photo cell against the purging air pressure, yet transmits light rays of the correct wave lengths for proper operation of the cell. The compressed air which purges and cools the inner and outer tube is introduced at approximately eight to nine pounds so that a continuous flow will be maintained when the tube is immersed in the bath, preventing the admission of molten steel and slag into the immersion orifice.

The operator places the end of the air purged immersion tube through the door wicket and dips the end of the tube into the slag once or twice so that the slag adheres to the tip of the tube; slag coating protects the tube. He then lowers the tube into the bath so that it is immersed about six inches in the molten steel. Air flow through the tube provides cooling and also prevents the admission of the molten slag and steel.

The air forms a cavity in the steel into which the photo electric cell is sighted. As soon as the end of the tube is submerged in the steel, the operator depresses the pushbutton on the tube for several seconds or until the instrument pointer comes to rest. The tube is then removed from the furnace and adhering slag or steel is scraped off on the wicket hole as the tube is withdrawn. This entire operation does not take longer than 10 seconds. It usually requires about two to three seconds to slag the tube and another four to five seconds to complete the measurement and remove the tube from the molten steel.

TYPE A PEERLESS PUMPS

TYPE A for

A*ll purposes.* For widest variety of general services. Handle water and alkaline fluids where no solids are in suspension.

A*dvanced design.* Double suction, single stage, horizontal split case construction. Ball bearing type. Dayton-Dowd design.

A*ll capacities and heads.* Sizes 1¼" to 48". For capacities up to 70,000 g.p.m.; heads up to 300 feet; temperatures up to 250 F.

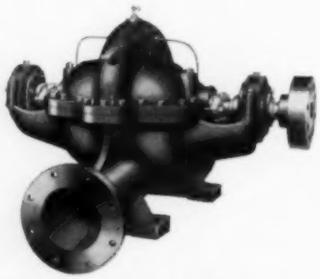
A*mple safety factors.* Component parts designed to afford high safety factor in operation and to extend pump life.

A*ccuracy in construction.* All parts machined to gauge on an interchangeable part system. Rigidly inspected in process.

A*ugmented service life.* Fully tested in Peerless' modern hydraulic laboratory to assure meeting or surpassing customers' application requirements.

FOR GENERAL PURPOSE PUMPING

When there's a pump in your plans, plan with a Peerless Type A General Service pump. Because of the large ranges in size, from 1¼" to 48", the widest range of applications is possible. There is a Type A pump with the capacity rating, head characteristics and type of drive to meet the requirements of most water pumping services in all industries.



Write for Bulletin describing and illustrating the design and application of Peerless Type A pumps.

fmc

PEERLESS PUMPS

PEERLESS PUMP DIVISION

FOOD MACHINERY AND CHEMICAL CORPORATION

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The recorder is usually located on the instrument panel for each furnace or on a separate panel which is clearly visible to the operator when using the tube.

COLUMBIA ACQUIRES SITE FOR COLD SHEET MILL

▲ Columbia Steel Company took possession on October 22 from the War Assets Administration of the site of its future cold reduction sheet mill in the Los Angeles district. First announcement of this project was made about a year ago. This site, located near Columbia's existing steel mill at Torrance, California, consists of more than 200 acres of land and various buildings which were used to house an aluminum plant during the late war. These buildings, which are now practically vacant, will be reconstructed and re-arranged to serve the needs of a modern sheet steel mill. Work on such reconstruction will commence immediately.

The equipment for the new sheet mill has been under order for many months and is now being manufactured. It is expected that the mill will be completed and in operation sometime in 1950. The mill will employ approximately 1500 men.

The new cold reduction mill will be the most modern of its kind in this country. It will have an annual capacity for the production of over 300,000 tons of cold reduced sheets of various kinds. This sheet mill will be similar to Columbia's new mill at Pittsburg, California, except that its production will be confined to sheets, for which there is a large demand in the Los Angeles area. There is no sheet mill of this character in southern California.

PRECIPITATOR REMOVES DUST ELECTROSTATICALLY

▲ Exceptionally high "around-the-clock" efficiencies, not previously obtained, have been achieved in the recovery and/or removal of entrained solid or liquid particles from industrial gases with Koppers-Elex electrostatic precipitators, already proved in a number of widely different installations.

These large units for industry are the newest products of the Koppers Company's Baltimore plant, which has engineered and manufactured industrial equipment for more than 110 years.

The precipitators can be furnished for a great variety of uses, and the installations now in service represent diverse applications. Their introduction to American industry assures purchasers of industrial precipitators that results, when guaranteed, will be accomplished.

In all cases where the new precipitators have undergone complete tests, they have exceeded guaranteed efficiencies and in all cases efficiencies have been 95 per cent. These are not efficiencies determined only during undisturbed precipitation, as generally the case in the past. The tests of Kopper's equipment cover full 24-hour periods, including operation when collected material is discharged from the electrodes.

Maximum removal of solids or liquids from industrial gases to meet the ever-increasing demand for minimum residuals exhausted to the atmosphere requires the highest electrical precipitation technique. Koppers-Elex employs proved precipitation techniques which, combined with

BIGGER LOADS...MORE TRIPS
The Blaw-Knox line of Heavy-Duty, Four-Rope Buckets includes many specialized designs for fast rehandling of ore, coal, slag, etc.... Capacities up to 25 tons. From the array of buckets listed and illustrated in Catalog No. 2059 you will find the one that fills your requirements exactly. Send for a copy.
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Stamping Dies

"Supreme" Steel
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Famous in the steel industry for their durability and "good impressions," these Pannier "Master Markers" are *still* your best bet for efficient and clear-cut marking of steel and steel products. Write for full information today.

Extra Fillet, Double Bevel Steel Stamps — letter, figure, symbol, name.

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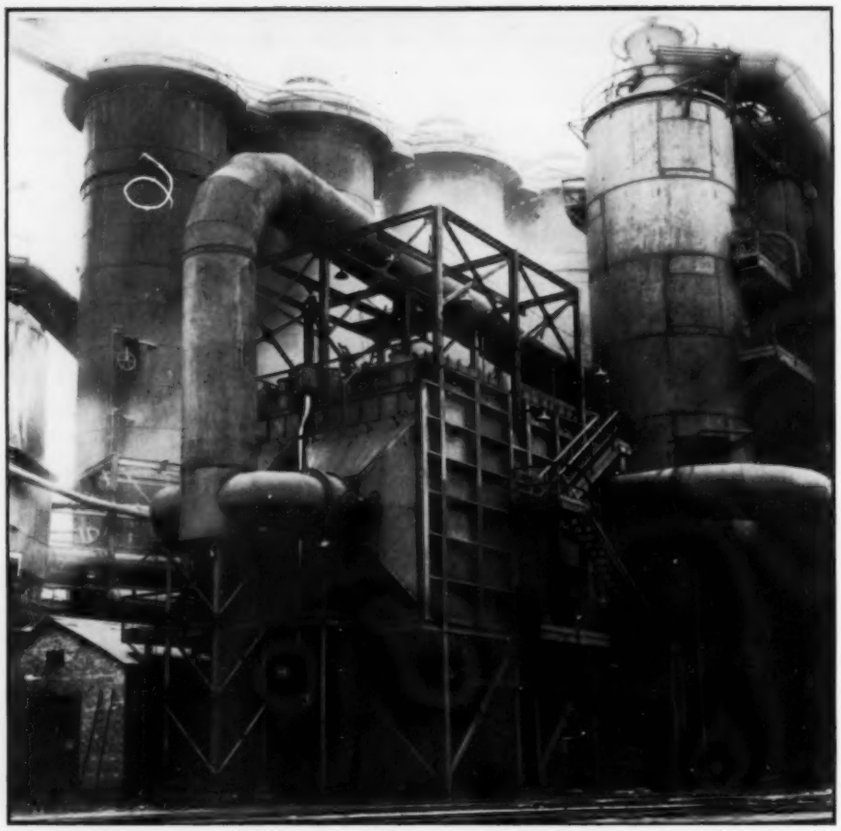
THE PANNIER CORPORATION
302 Pannier Building
Pittsburgh 12, Pa.



Smoke control programs in various communities have advanced the use of electro-static precipitators for removal of dust from industrial gases. The use in industry has improved fuel efficiency in the cleaning of blast furnace gas.

proper gas velocity and, relatively important, the time the gas and its entrainment is subjected to the electrical high voltage discharge, insure compliance with required performance. Such design approach naturally requires larger units and improved precipitation elements. However, the precipitators are so designed as to provide the utmost economical performance in line with requirements. This is true whether the precipitators are for maximum recovery for re-use or sale; for refinement of gas for more efficient use; or solely for nuisance abatement to meet municipal ordinances.

Koppers-Elex precipitators are designed to meet specific requirements, and vary accordingly. Types include:

1. For removal and recovery of tar oil and water from coke oven, producer, and carburetted water gases. This precipitator also serves the necessary purpose of gas refinement, thereby materially improving overall plant operation.

2. For cleaning blast furnace gas to improve its efficiency as a fuel in the operation of stoves, coke ovens, generators, boilers, etc. Varying degrees of cleaning are required. Stoves of today with smaller tile openings and coke ovens of the underjet type require considerably lower residuals than other equipment.

3. A precipitator for use in metallurgical operations. In such installations valuable metallic products are recovered from gases emanating from reverberatory, electric, roasting, and sintering furnaces.

4. A most important type of precipitator is offered for the removal of fly ash from power plant boiler gas. The main function of this unit is to abate nuisance and enable power plants to comply with strict municipal ordinances.

Public consciousness has been turning for some time to the eradication of smoke from our industrial cities. A number of larger cities have passed smoke abatement ordinances, and such ordinances have presented large industries with a major problem. Requirements under them vary widely and, in many cases, the results achieved do not now satisfy the public.

While residuals permissible under widely varying ordinances range from .25 grain to .75 grain per cu ft, .25 grain is being urged as the maximum acceptable residual. However, cor-

porations, realizing that such specification is too liberal and will not free them from possible court action, are specifying maximums of .15 grain per cu ft.

Such residuals are possible only with an electrostatic precipitator. Therefore, as more and more cities adopt strict smoke abatement ordinances as health and cleanliness measures, there will be an increasing demand for the removal of industrial fly ash by electrostatic precipitation.

An official test result from a Koppers-Elex precipitator installation, indicating the efficiency of design, shows:

Blast furnace type precipitator at a mid-western steel plant: Gas volume—80,000 cfm; guaranteed efficiency, 95 per cent; actual efficiency, 98.5 to 99.4 per cent; required residual, .015; actual residual, .002 to .00048 grains per cu ft.

SYRACUSE PLANTS FINISH IMPROVEMENT PROGRAM

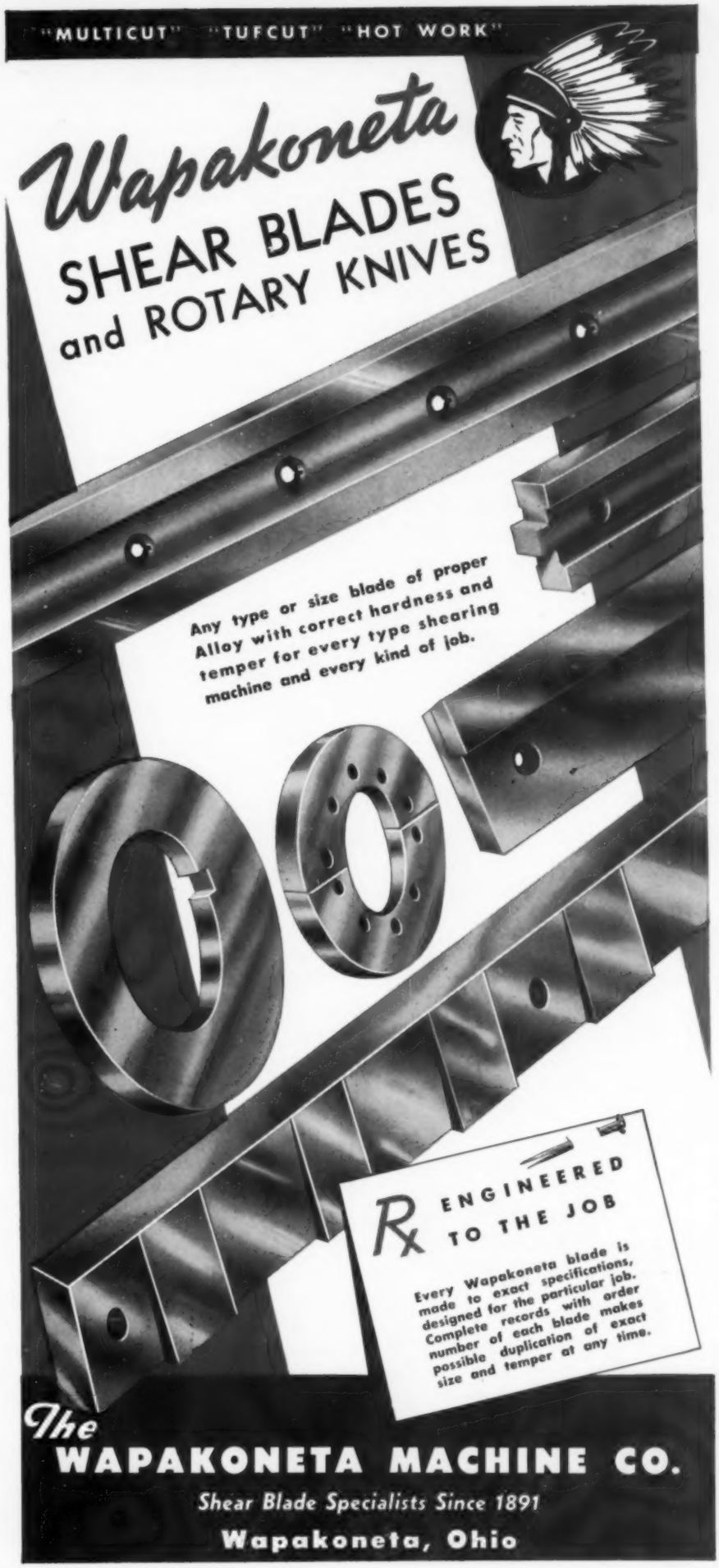
▲ The art and craftsmanship traditionally found in making fine steels to the most precise requirements of industry are essential elements in the operations of the Sanderson-Halcomb works of Crucible Steel Company of America, situated on a 100-acre site at Syracuse, New York.

The Sanderson-Halcomb works has largely completed a $3,600,000 program of plant improvements and expansion, is one of six Crucible Steel manufacturing centers. These plants combine to make the company the country's leading producer of high-speed, tool, specialty-alloy, stainless, machinery and super-alloy steels.

The company as a whole has substantially carried through a program of plant improvements and expansion, initiated in 1946 and calling for expenditures of well over $30,000,000.

The Sanderson-Halcomb works now incorporates manufacturing operations formerly located at other Syracuse locations, the Sanderson plant and the Emerson Avenue plant. Equipment was transferred to the enlarged Sanderson-Halcomb works and, in addition, a complete modernization and production improvements program has been put through in all major details.

The melt shop of the plant is comprised of four electric furnaces with an output measured in thousands of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SHEAR BLADES
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Any type or size blade of proper Alloy with correct hardness and temper for every type shearing machine and every kind of job.
Rx ENGINEERED TO THE JOB
Every Wapakoneta blade is made to exact specifications, designed for the particular job. Complete records with order number of each blade makes possible duplication of exact size and temper at any time.
The WAPAKONETA MACHINE CO.
Shear Blade Specialists Since 1891
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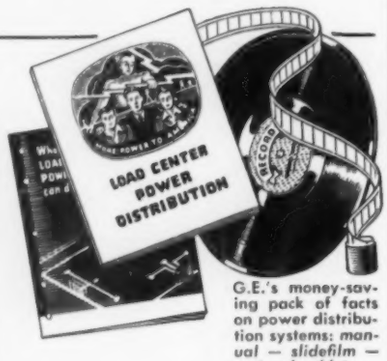
One manufacturer saved $10,400 in power equipment—*CAN YOU?*



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GENERAL ELECTRIC

tons per month, as well as other special melting equipment for smaller heats. A large variety of analyses — combinations of steel and costly alloying elements such as chromium, tungsten, cobalt, nickel, molybdenum and others — are made in the Sanderson-Halcomb works. Well over 300 different combinations, all carefully controlled and checked in the process by means of the latest metallurgical instruments, are melted here in the course of filling industrial requirements.

After the steel is melted and "teemed" into ingots, it goes through the "cogging" processes — either rolling mills or hammers — the first step toward special processing and finishing. Here the steel is transformed into billets.

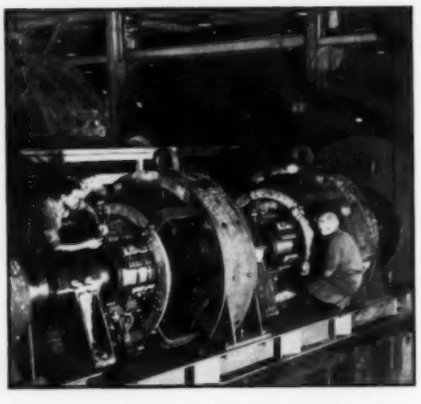
The $3,600,000 plant improvement program in the Sanderson-Halcomb works touches every department of the plant. The wire mill and tool bit departments are operating in new, enlarged quarters — with modernized, and much new equipment.

In the melt shop, three top charged 6-ton electric furnaces have been installed as replacements.

Cogging mills, rolling mills and hammers have been integrated into the Sanderson-Halcomb works to provide the widest possible range of process capability.

The bar finishing facilities, inspection department, cleaning operations and materials handling facilities of the plant all have been improved and enlarged.

MG SET FOR BELGIUM



When completed at the General Electric plant at Schenectady, New York, this six unit motor-generator set now being tested will drive the largest reversing cold strip steel mill in Belgium. The generators will provide adjustable voltage to drive mill and reel motors at varying speeds. The set operates in conjunction with an elaborate system of amplidyne control and is driven by a 4000-hp synchronous motor.

PHOSPHATE MATERIAL INCREASES DRAWING SPEED

▲ Metallurgists of the Jones and Laughlin Steel Corporation report that a new phosphate material which inhibits rust and helps lubricate wire in process now permits a 20 to 25 per cent increase in speed of drawing fine high-carbon wire.

The new material, known as "Banox" and described by the manufacturer, Calgon, Incorporated, as an amorphous metaphosphate compound, has been in use at J & L's Aliquippa, Pennsylvania, wire mill since June, 1947. Calgon service engineers reports this is the first application of this material in wire-drawing, although it has been effectively employed by manufacturers as a rust-proofing and paint-bonding coating prior to painting. Protection of the wire against rusting while in process not only has permitted an increase in drawing speed but also has meant a sharp reduction in damage to dies and to wire, and fewer delays for replacing and restringing dies, the J & L metallurgists explain.

Because the film deposited on the wire is not water-soluble, and assures a degree of lubrication for the wire in subsequent drawing, the amount of lime picked up to carry lubricant is not critical as in conventional practice, it is added. Formerly, a light coat of lime or a too-heavy "flaky" coat required redipping of the coil; otherwise, too little lime frequently resulted in insufficient lubrication, with damage to dies and wire, and too

The new phosphate material permits a 20 to 25 per cent increase in speed of drawing fine high-carbon wire.

heavy a lime coat would flake off, exposing bare wire with much the same results.

At the Aliquippa works the coils of high-carbon wire destined for wet drawing to fine sizes are dipped successively in an 8 to 10 per cent sulphuric acid pickle; a water rinse; a 1 per cent "Banox" solution for 4 minutes; another water rinse, and a bath of 8 to 9 per cent hydrated lime. Drying in a flash baker is the final step. This high-carbon material usually is .028 in. to .066 in. in size when readied for final reduction on the Vaughn wet-drawing machines. Finished sizes often are on the order of .007 in.

RADIANT GAS FURNACES PRODUCE ECONOMIES

By M. L. SNODGRASS
Gas Machinery Company

▲ Here is a typical comparative performance table showing the economies obtained with Gas Machinery Company's radiant tube and roller hearth annealing furnace as compared with the batch type furnace it replaced. This furnace is being used to anneal stainless steel tubing at 2000 F in an air atmosphere.

	Batch type gas fired furnace	Gas fired tube and roller hearth furnace
Tons annealed	2,435	467
Manhours	9,652	832
Tons per manhour	0.252	0.562
Furnace operating hours	4,826	832
Heating rate — lb per sq ft per hr	9	30
Average annealing fuel cost per ton	$2.93	$1.86

These radiant tube and roller hearth furnaces are built to specification for the job to be done in many sizes from 1 ft 6 in. x 3 ft to 5 ft 6 in. x 70 ft hearths and at substantial savings in fuel, labor and increased production.

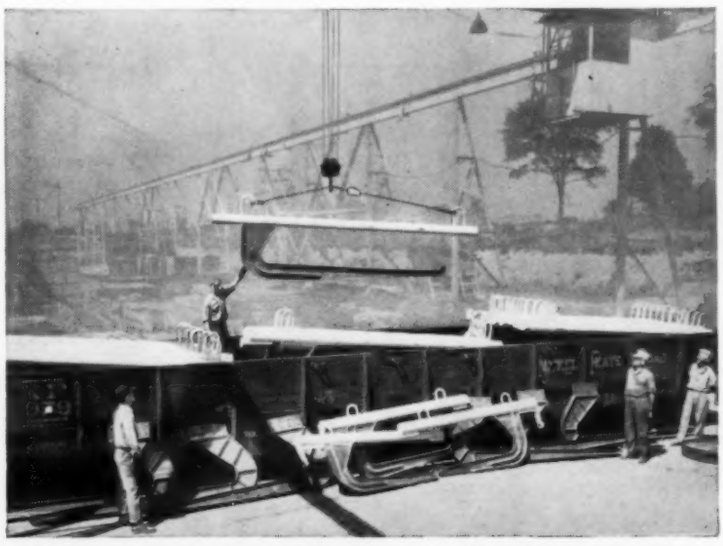
For low-cost heat treating in controlled atmospheres between 1700 and 2500 F and over, Gas Machinery furnaces are setting new records. Design and construction is soundly based on 45 years experience in furnace building.

These furnaces are job-tailored for annealing; heating and heat treatment of alloy metals; brazing; sintering of powdered metals; high temperature anneal of magnet metals; heat treatment of newer alloys for jet and turbo engines. Also, there are economical applications in the process, ceramic, ore treatment, and allied industries.

All furnace installations can be designed to include auxiliary equipment necessary for maximum efficiency such as, quench tanks, conveyors, manipulators and charging machinery.

SILICON STEEL FACILITIES MODERNIZED AT C-I PLANT

▲ Completion of a modernization program for increased production



LIGHTWEIGHT HOOKS *for* HEAVY-DUTY SERVICE

WELDCO HAIRPIN HOOKS SPEED UP YOUR PICKLING AND MATERIAL HANDLING OPERATIONS

● Here's another carload of Weldco hairpin hooks, ready for shipment to one of the country's largest steel plants. These pickling hooks are lightweight but tough . . . designed to handle loads as heavy as 3,000 to 5,000 pounds, easily and safely. Weldco hairpin hooks withstand hot pickling acids, too; in fact, they're more corrosion-resistant—more durable—than many heavier hooks.

Weldco pickling hooks are made of Monel, and can be furnished in various other alloys. Put these sturdy, lightweight hooks to work in your plant—then watch your pickling and material handling costs go down.

OTHER WELDCO PICKLING PRODUCTS
Include Pickling Crates, Baskets, Chains, Jets, Scrubbers, and Mechanical Picklers
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of silicon steels for the electrical industry was announced by Carnegie-Illinois Steel Corporation. At the same time, operation of out-moded galvanizing facilities at the Vandergrift, Pennsylvania plant of this U. S. Steel subsidiary has been discontinued.

Two new continuous type coil annealing lines have started initial operation, marking the completion of installation work on new facilities for making silicon steel for transformers, motors and generators. The improvement program was undertaken to strengthen the plant's competitive position.

An increase in the production of silicon sheets at Vandergrift is expected from the new facilities, insuring the plant's continuance as a leading producer in this field.

Discontinuance of galvanizing operations will involve the transfer of about 150 employees to other departments at Vandergrift and to other plants of Carnegie-Illinois in the Pittsburgh district.

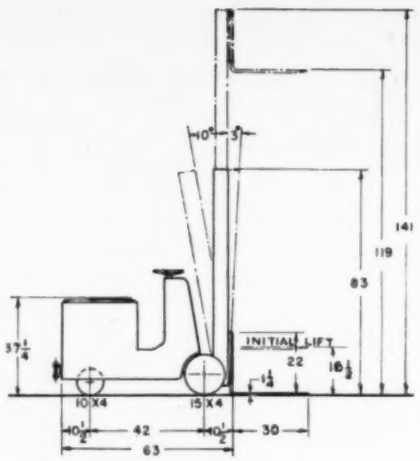
Electrical steels are heat treated in coil form in the new continuous annealing lines, using electric heat radiation. Other equipment recently installed at the plant for the production of silicon steels includes a 54-in. cold reduction mill, a temper rolling mill, auxiliary slitting and shearing lines and a gas-fired continuous annealing line.

LOW-PRICED FORK TRUCK FOR NARROW AISLE USAGE

▲ The Baker Industrial truck division of Baker-Raulang Company has announced a center-control fork truck designed to meet the need for a light-weight, low-priced fork truck in the 2000 lb field. In appearance and design it closely follows the FQH 1000 lb capacity fork truck which was announced about 10 months ago.

This truck finds application in all plants where narrow aisles, congested areas, limited floor capacity, small and low capacity elevators are a factor and wherever loads can be limited to 2000 lb, 36 in. long.

This new fork truck has a 42 in. wheelbase, a 30 in. width, and an overall length exclusive of forks of 63 in. To make a right angle turn the truck requires only 76½ in. plus the length of the load. This compact construction makes available the advantages of power fork truck operation to a large class of users whose conditions prevent them from using the larger type of power industrial truck equipment.



To make a right angle turn the truck requires only 76½ in. plus the load.

CONTROL SHEET EDGES BY MECHANICAL MEANS

▲ The edge position of any sheet-like material entering a process over rollers can now be controlled within limits as narrow as ±.05 inches by

Completely split pulley

Extra heavy conveyor pulley

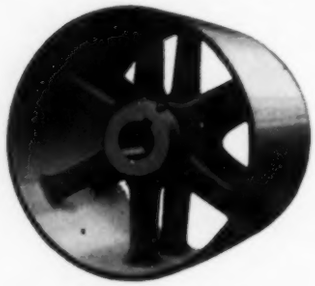
High test cast iron pulleys in all sizes and types

JONES cast iron pulleys are true running — they permit higher speeds — no bushings and they can't fall apart — they don't rattle and they look better on most machines.

These pulleys are machine molded, poured of high test cast iron, and are accurately finished and balanced. Multiple piece pulleys, rubber covered pulleys and flywheels can be furnished.

W. A. JONES FOUNDRY & MACHINE CO.
4431 Roosevelt Road, Chicago, Illinois

Single arm solid pulley



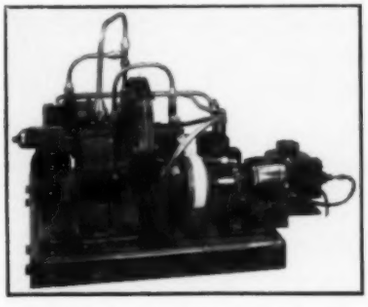
Double arm pulley

Jones

HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS • PULLEYS
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • TRANSMISSION APPLIANCES

simple mechanical means and without touching the sheet. Any process in which coating, coiling, or an endless belt conveyor is used can be improved by Askania Regulator Company's new edge positioner which controls the position of the sheet on the roller.

A new combination of standard control components, with the addition of a pair of air nozzles, does the job. The nozzles are used to pass a narrow stream of air past one edge of the sheet. The air comes from one nozzle and is received by the other, which is connected to the diaphragm of a standard pressure regulator. The sheet moving between the air nozzles cuts a certain amount of the flow of air to give an impulse to the diaphragm. This impulse is transmitted to the diaphragm of the regulator



The regulator is shown at left with a small model sheet being operated on two crowned rollers.

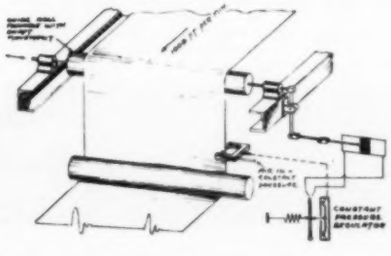
which then supplies power to a cylinder to change the position of the sheet on the roller either by pivoting the axle of the roller or by moving it from side to side. When the sheet moves to the right or left, it cuts off more or less of the air flow, changing the impulse on the regulator until a control position is reached.

In the case of an endless belt conveyor, which has a crowned roller, advantage is taken of the fact that a sheet will tend to center about the top of the crown. By pivoting the axle of the roller, the cylinder actually changes the position of the top of the crown in order to change the position of the sheet in response to the air flow impulse on the diaphragm of the regulator.

In the case of coiling or coating, the cylinder tilts the roller to move sheet to the right or left, in proportion to the change of impulse on the diaphragm.

The position of the air nozzles can be changed with a handwheel, in order to change the desired position of the sheet in relation to the center of the roll. When the air nozzles are moved to one side or the other, the sheet will follow them until the proper controlling impulse is received by the diaphragm of the pressure regulator.

A new combination of control components, with the addition of air nozzles, does the job.



OXYGEN TEST PLANT COMMENCES OPERATION

▲ The first plant designed and constructed in this country for the production of low-purity oxygen for use in blast furnaces has commenced operation at the Johnstown works of Bethlehem Steel Company, it was announced jointly by Air Reduction Company, Incorporated, Bethlehem Steel Company and Koppers Company, Incorporated. The equipment was designed by Air Reduction and its installation was handled by Koppers. The output of the plant will be

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The World's Standard Inhibitor...!

Rodine in the pickle bath—either batch or continuous—means improved pickling and lower costs because "Rodine" . . .

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SAVES both acid and metal
PROMOTES scale removal
PROLONGS the life of the pickle bath
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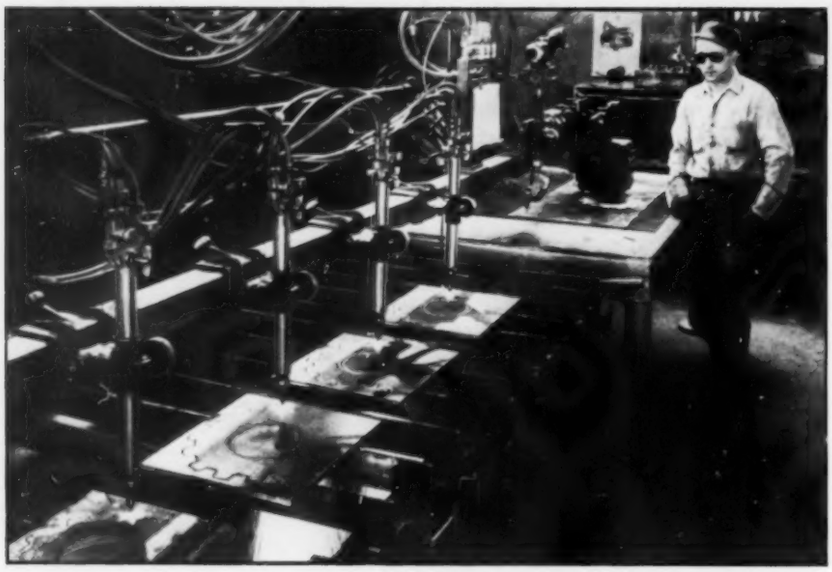
REDUCES hydrogen embrittlement
PRODUCES cleaner, brighter, smoother surfaces
MINIMIZES acid fumes
IMPROVES working conditions
BOOSTS pickling production

"Rodine" more than pays for itself in savings of acid and metal.

Pioneering Research and Development Since 1914
AMERICAN CHEMICAL PAINT COMPANY
AMBLER, PA.
Manufacturers of Metallurgical, Agricultural and Pharmaceutical Chemicals



A steel distributor in Syracuse, New York, noted a growing number of requests from customers which asked for special shapes. To help them handle this type of order this progressive firm decided to purchase a pantagraph type oxyacetylene gas cutting unit, the Air Reduction "6B Oxygraph." Using a four-torch setup equipped with an electronic tracing device this machine will cut plates into circles, squares and irregular shapes on a fast production basis.

taken by Bethlehem Steel Company for experimentation in the use of oxygen for the enrichment of the air blast in blast furnaces.

When, as a result of this research, significant data have been accumulated, they will be made available to the steel industry.

METAL CARBIDE USE IS SPREADING RAPIDLY

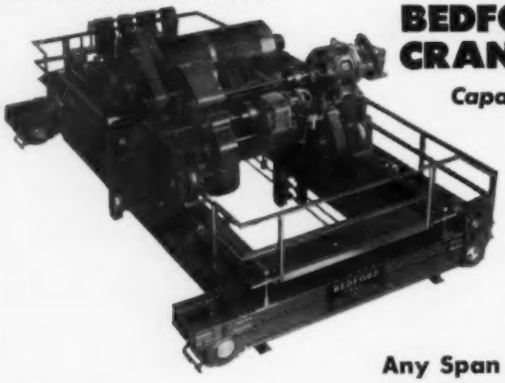
▲ From cutting tools and dies for wire and tube drawing, use of hard metal carbides, as manufactured by Carboloy Company, is spreading rapidly into many diversified fields. Carbide inserts and specially designed carbide parts are coming to be used in more and more places where undue wear from rubbing and abrasion is a problem. This trend is so pronounced that it appears likely that the use of carbide metal for non-cutting-tool purposes may eventually exceed even the tremendous volume of carbides now used for cutting tools. The reason for this is obvious; when carbides — under conditions of extremely abrasive wear — demonstrate their ability, time after time, to stand up 100 and even more times longer than other metals.

First commercial use of hard metals was as a die material for the drawing of round wire. Today, carbide dies are standard equipment throughout the entire wire drawing industry. In addi-

CRANE BUILDERS Since 1903

BEDFORD CRANES

Capacities 5 to 150 Tons



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GANTRY CRANES • STEEL DERRICKS
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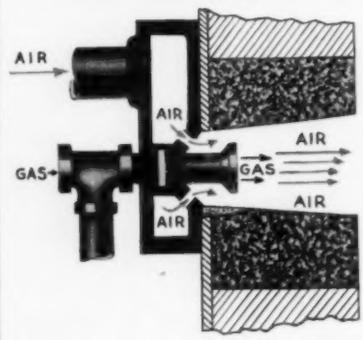
BEDFORD FOUNDRY & MACHINE CO.
Engineers Designers Fabricators
BEDFORD, INDIANA
U. S. A.
Gray Iron Castings

THE BLOOM TEMPERED-FLAME BURNER

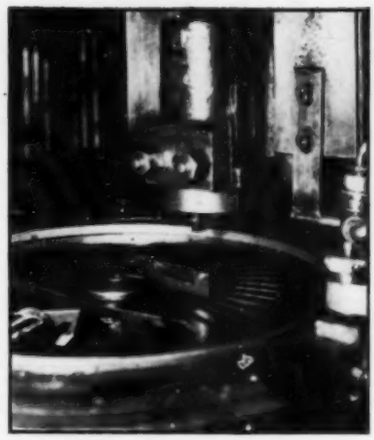


BURNS AS LONG AS IT HAS FUEL!

Providing unparalleled flexibility of furnace operation, the Bloom Tempered-Flame Burner can be used for furnace temperatures from 2600°F to 400°F. It will light at full capacity, and will not go out as long as fuel is supplied. It operates with great stability throughout all ranges of fuel-air ratios. A unique principle of design gives this highly valuable flexibility.

Full details will be furnished upon request.

BLOOM ENGINEERING CO.
857 W. North Avenue Pittsburgh 12, Pa.



Carbide outlasts tool steel for non-cutting tool purposes.

tion, carbide metal is widely used in the wire industry for such machine parts as guide bushings, tension pins, wire flattening blocks, pulley segments, staple clinchers, outrigger guide inserts, etc.

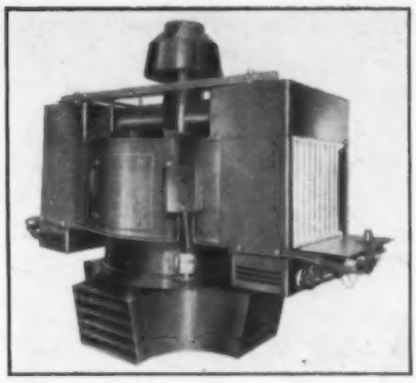
Carbide dies for the deep drawing of many kinds of sheet metal, including plain carbon steel, stainless steel, alloy steel, brass, bronze, aluminum and tin, are also finding increasing favor since such dies usually outlast from 20 to 100 similar dies made of hardened tool steel.

REVOLVING UNIT HEATER IS SELF-CONTAINED

▲ A new, self-contained gas-fired revolving unit heater has been announced by the L. J. Wing Manufacturing Company, originators of the revolving unit heater. Using either natural or manufactured gas, the heater combines gas burners, heat exchanger and combustion chamber with a motor-driven "Wingfoil" fan and revolving discharge outlets.

Designed for overhead location, it projects the heated air to the working level and by means of the revolving outlets circulates the warmth in all directions, under obstacles, into pits, and reaches into the farthermost corners.

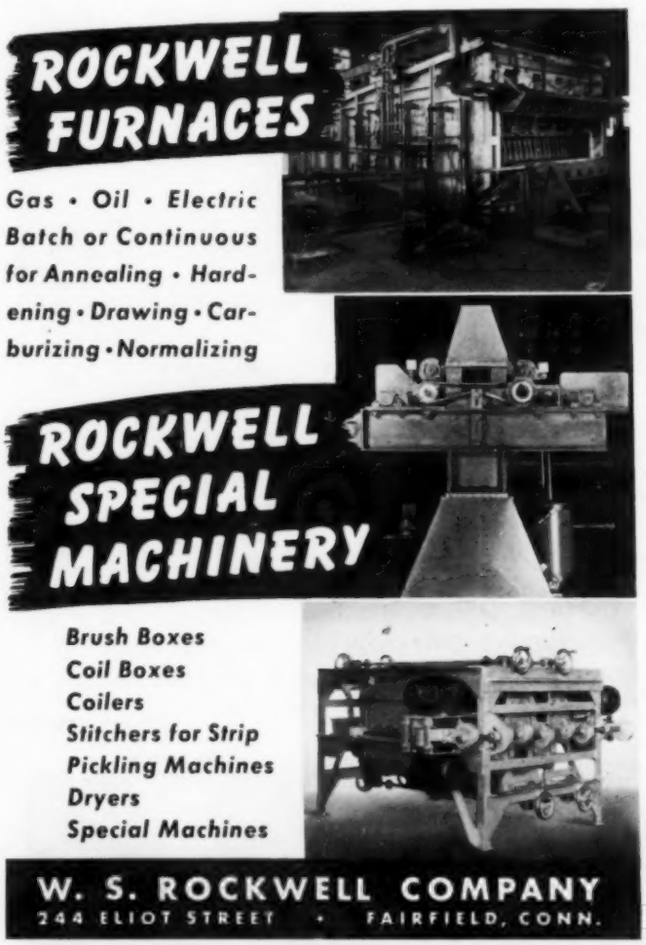
Even in the summer these heaters are at work, but here they become a cooling device by simply turning off the gas and turning the fans on. The air is circulated in the same manner as the heated air in the winter, creating a pleasing sensation of relief from oppressive stifling heat.

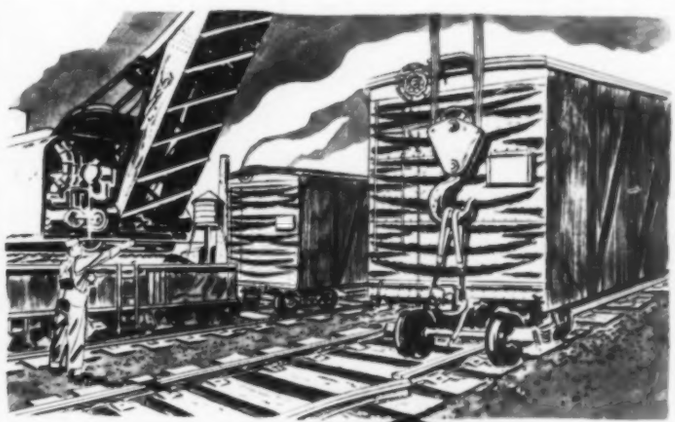


These heaters circulate warmth in all directions.

The gas-fired revolving unit heater is a ruggedly constructed piece of equipment. Heat exchanger and combustion chamber of grey iron are cast together in one piece. No gaskets are required, nothing to burn out or to disintegrate. Extended heating surface fins on the heat exchanger are cast integral, nothing to move, or loosen. Burners are constructed of grey iron with drilled ports.

(*Please turn to page 168*)





Derailments Are Costly.

We are engaged in both construction and maintenance of railroad side tracks. Our organization has thoroughly trained former railroad personnel. They all have had years of track-laying and maintenance experience.

We are equipped to survey your track layout; then set up a complete program for the necessary repairs, rehabilitation and future maintenance.

RAILROAD SIDING CONSTRUCTION CO.
716 CLARK BUILDING
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Aluminum Bus Conductor costs less per amp., per foot

You pay less per foot for aluminum bus conductors than for bus conductors made of any other metal.

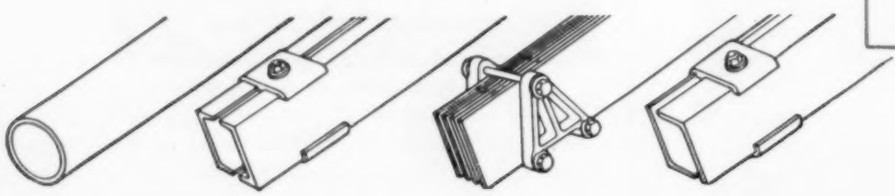
The four popular types of Alcoa Bus Conductors—in all standard sizes—are flat bars, angles, tubes, and channels.

Write today for engineering data on Alcoa Aluminum Bus Conductors. ALUMINUM COMPANY OF AMERICA, 2128 Gulf Building, Pittsburgh 19, Pennsylvania.

LIGHTER...
fewer supports and insulators, lower freight and handling costs.

EASY TO FABRICATE...
only standard tools needed, less man power and equipment to install.

RESISTS CORROSION...
non-staining, requires less cleaning, looks better.

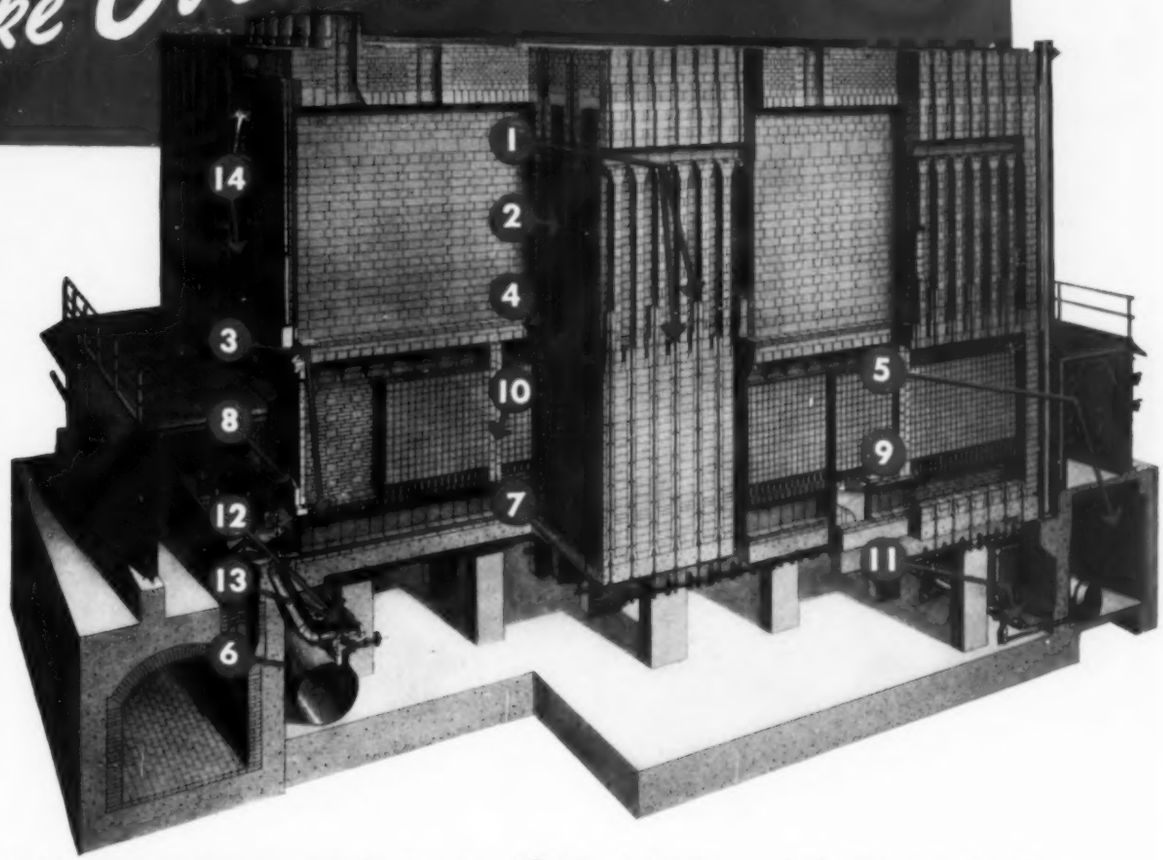


ALCOA FIRST IN **ALUMINUM**

ALCOA ALUMINUM 1888 1948 60 YEARS OF SERVICE

Some of the Reasons

why WILPUTTE Coke Ovens are Superior



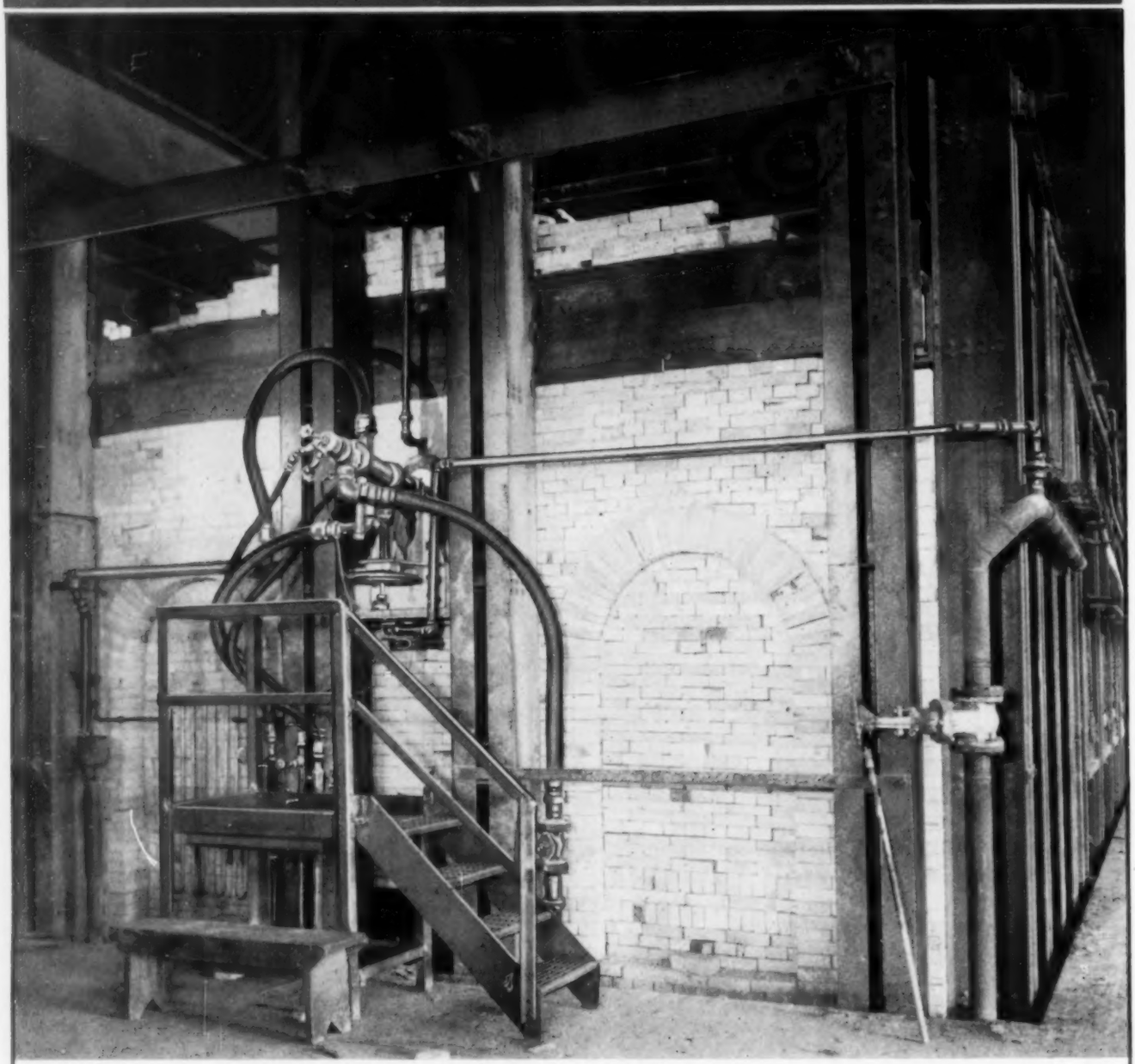
1. Alternating high and low burners—*vertical uniformity in rich gas heating.*
2. Walls of unstepped thickness—*vertical uniformity in heating with lean gas.*
3. Venturi ports—*air, lean gas, and waste gases distributed uniformly through regenerators.*
4. Graduated air ports—*built-in regulation of air and lean gas.*
5. Combustion air system—*accurate control of combustion air, uniform ventilation of basement.*
6. Orifice and butterfly—*lean gas at equal flow to each regenerator.*
7. Stainless steel pins—*precision distribution of rich gas to the burners, readily accessible for cleaning.*
8. Insulated steel face panels—*air tight, reduce loss of heat from regenerators.*
9. Metal flashing—*no leakage between bus flues.*
10. Short division walls, triple-thick—*the only regenerator area subject to cross leakage.*
11. Forced air system—*positive control of decarbonizing of burners.*
12. Simple latch at each lean gas reversing valve—*change over entire battery from one gas to another within five minutes.*
13. Positive interlock at each gas reversing valve—*air and lean gas cannot be admitted at the same time.*
14. Self sealing oven doors and self sealing leveling doors with renewable sealing edges—*gas tight, easy maintenance.*
15. Hydraulic door machines—*smooth operation, low maintenance.*

WILPUTTE COKE OVEN DIVISION

ALLIED CHEMICAL & DYE CORPORATION

40 RECTOR STREET NEW YORK 6, N. Y.

CROWE BURNERS BOOST TONNAGE



The installation of Artillery Type Water Cooled Burners as shown on this page is located in the D.P.C. Plant at New Castle, Pa., which is leased and operated by the United Engineering and Foundry Company. Fuel used is oil and natural gas. Capacity of furnace is Seventy Five Tons per heat. Furnace redesigned and built by the Olson Engineering Co., Pittsburgh, Pa.

We build burners for any size furnace
and for any combination of fuels.

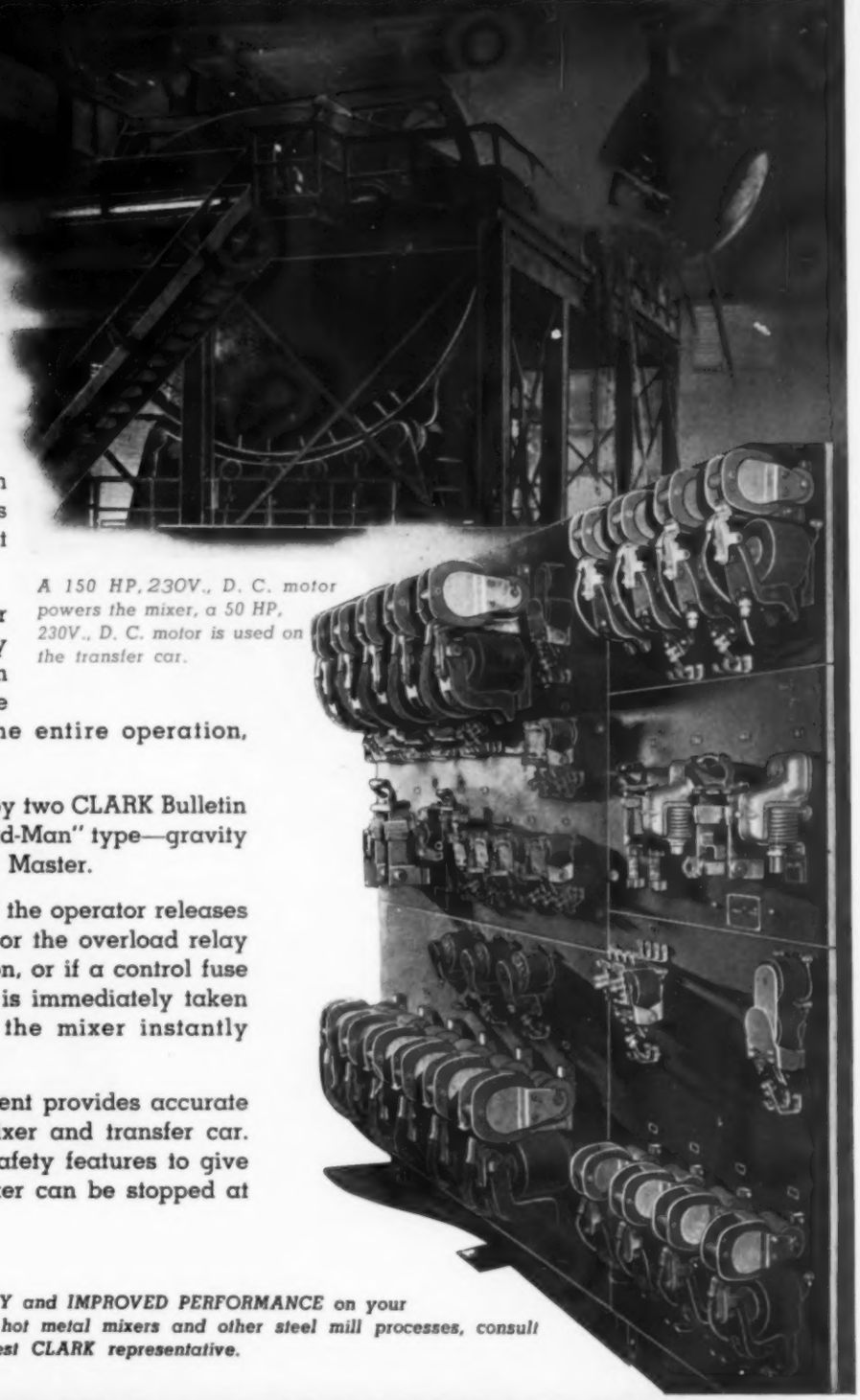
Manufactured by

THE CROWE ENGINEERING COMPANY
1838 Western Avenue
CINCINNATI 14, OHIO, U. S. A.

CLARK-BUILT CONTROL

adds SAFETY and IMPROVED PERFORMANCE

to Existing Hot Metal Mixers



Blending different "heats" from open hearth furnaces produces many types of alloy steel in hot metal mixers.

A 150 HP, 230V., D. C. motor powers the mixer, a 50 HP, 230V., D. C. motor is used on the transfer car.

Mixer tilting and transfer car movements are both controlled by the same operator stationed on the balcony. In this position he has a commanding view of the entire operation, insuring complete safety.

The hot metal mixer is actuated by two CLARK Bulletin 101 Master Switches. One is "Dead-Man" type—gravity return, the other the Operating Master.

The control is so designed that if the operator releases the "Dead-Man" Master Switch, or the overload relay trips during the pouring operation, or if a control fuse blows—the control of the mixer is immediately taken away from the operator and the mixer instantly returns to its "UP" position.

The CLARK Heavy-Duty Equipment provides accurate control for both—hot metal mixer and transfer car. It also incorporates additional safety features to give assurance that tilting of the mixer can be stopped at any time during pouring.

For SAFETY and IMPROVED PERFORMANCE on your EXISTING hot metal mixers and other steel mill processes, consult your nearest CLARK representative.

EVERYTHING UNDER CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152nd STREET, CLEVELAND 10, OHIO

INDESTRUCTIBLE . . .

PRESSURE-CAST ALUMINUM ROTORS

RELIANCE *Precision-Built* **MOTORS**

Color in this cutaway drawing highlights the Reliance pressure-cast aluminum rotor.

One of the many outstanding features that make Reliance *Precision-Built* Motors your best choice for dependable, long-lasting power is an indestructible rotor, pressure-cast in aluminum. This construction makes rotor bars, short circuiting rings and fan blades an integral section for rugged service requirements. Rotor cores of electric silicon steel are precision punched for greatest efficiency and the slots are skewed to provide quiet operation and uniform starting torque. For further facts on what *precision* means in Reliance *Precision-Built* Motors, write for Bulletin C-118.

Reliance Protected Open A-c. Motor.

Sales Representatives *in Principal Cities*

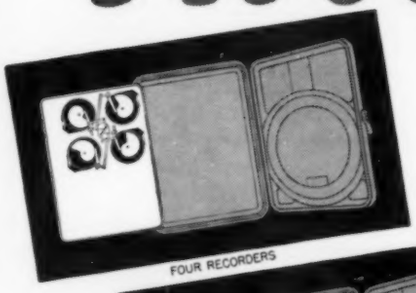
RELIANCE ELECTRIC AND ENGINEERING CO.

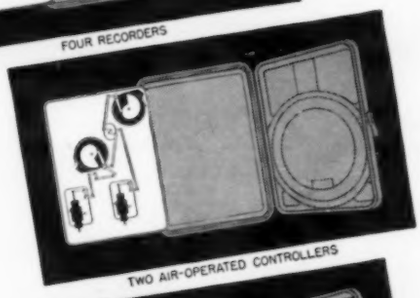
1084 IVANHOE ROAD • CLEVELAND 10, OHIO

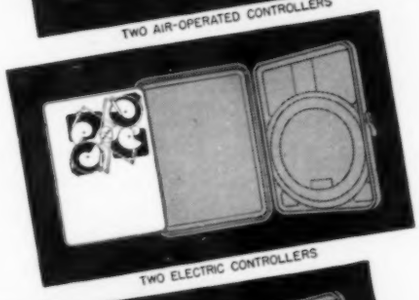
"Motor-Drive is More Than Power"

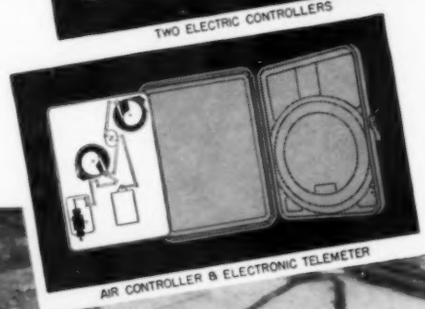
these and 100,000 more

FROM 4 CIRCUITS AND 8 BASIC PARTS


FOUR RECORDERS


TWO AIR-OPERATED CONTROLLERS


TWO ELECTRIC CONTROLLERS


AIR CONTROLLER & ELECTRONIC TELEMETER

What's your control problem? Flow—temperature—level? Are you using solids—liquids—gases?

No matter what you process, four basic circuits and eight basic component parts will give you more than 100,000 different electronic measuring and controlling combinations. That's how Bailey has simplified controls for processing industries.

The four arrangements illustrated show how easily Bailey interchangeable parts can be used. It's no longer necessary to carry a huge stock of replacement parts for emergency control installations. When you standardize on Bailey controls you are always ready to meet changing conditions within your plant.

And with Bailey simplified controls, your maintenance costs will be less. Maintenance men quickly become familiar with Bailey controls and spend less time on maintenance and installation.

To see for yourself how you can profit with Bailey controls, write for a copy of our bulletin No. 17.

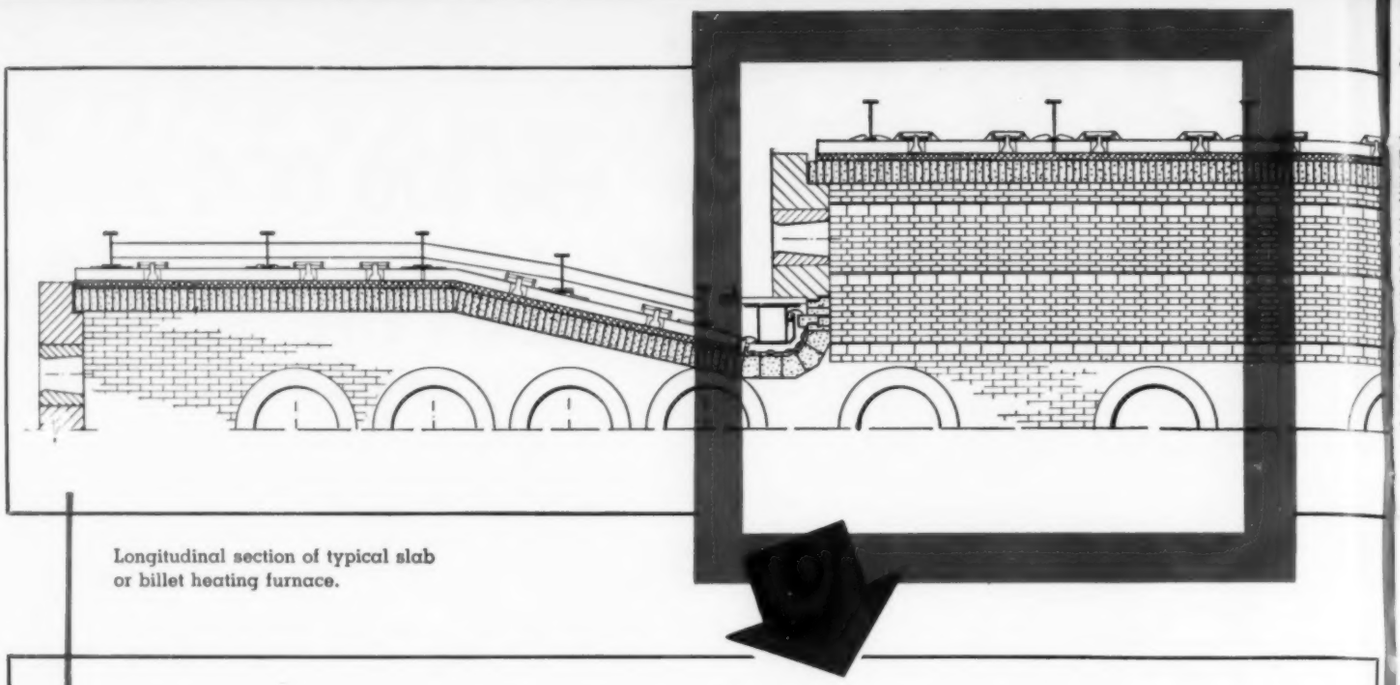
BAILEY METER CO.
1047 Ivanhoe Road • Cleveland, Ohio
BAILEY METER CO. LIMITED, MONTREAL

Controls for the Iron and Steel Industry

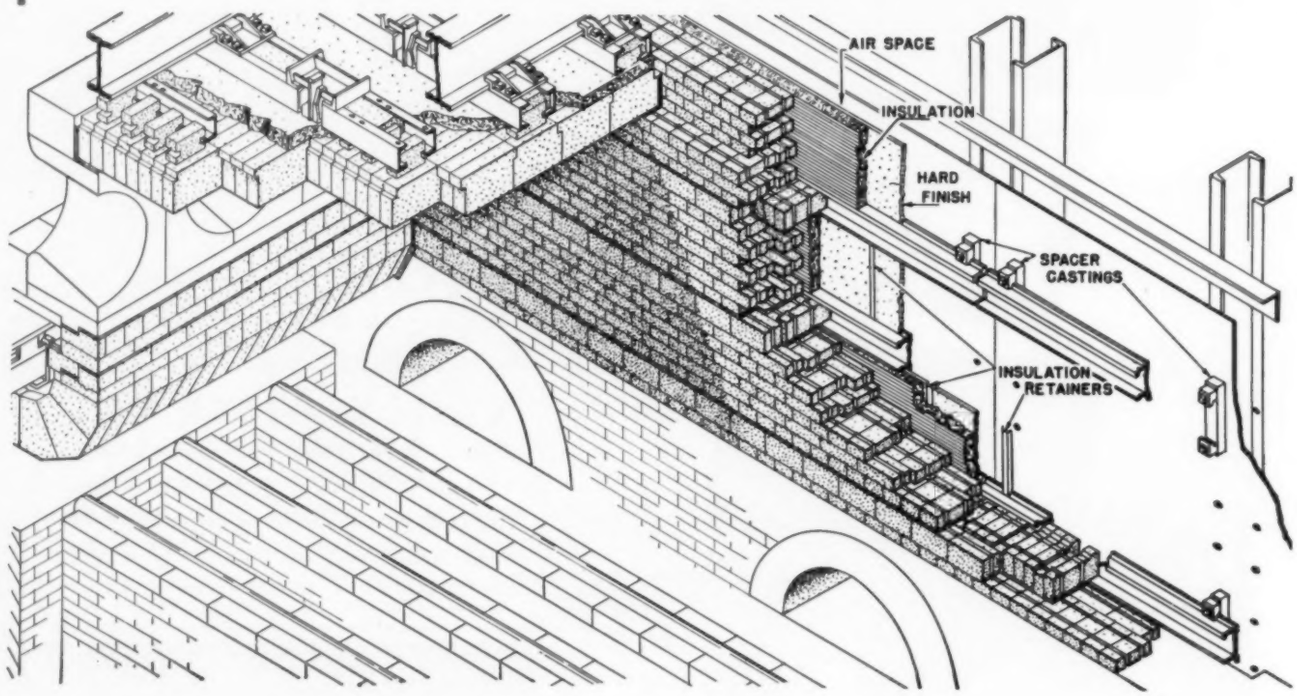
PRESSURE • FLOW • LEVEL
GAS ANALYSIS • TEMPERATURE • RATIO

P-17

4 + 8 works here at the Barberton Plant of Pittsburgh Plate Glass Company, Columbia Chemical Division

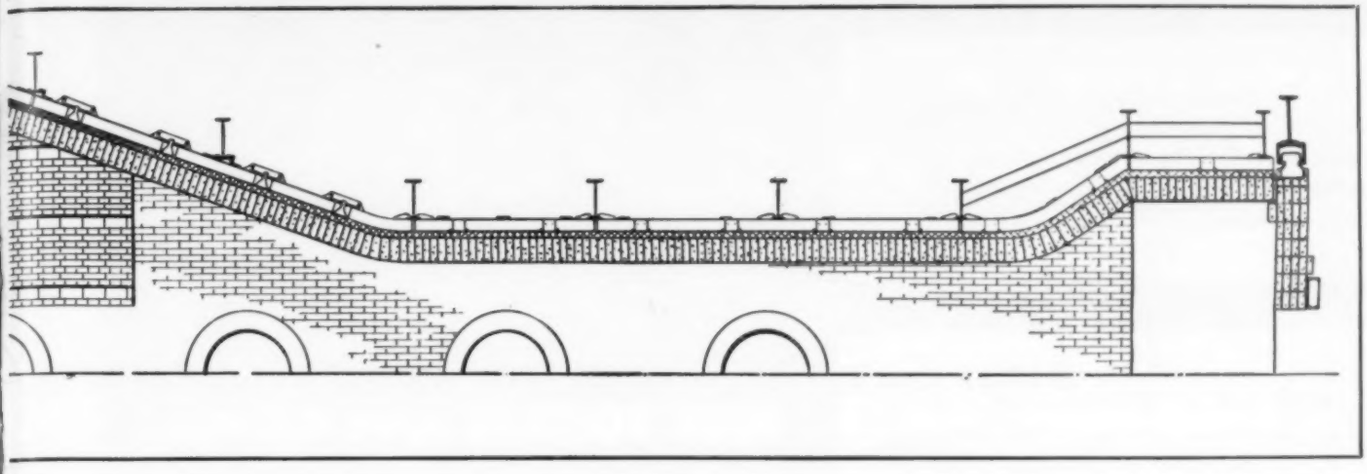


Longitudinal section of typical slab or billet heating furnace.



Inside view of heating zone.

AMERICAN ARCH
1430 Park Building, Pittsburgh, Pa.
REPRESENTATIVES: BIRMINGHAM • CHICAGO • CINCINNATI



American Sectionally-Supported Side Walls for steel plant furnaces

Outstanding advantages of American Type G lock-tile sectionally-supported construction for the side walls of furnaces —

Lock-tile construction, with tongues and grooves on four sides of the tile, insures air-tight and gas-tight walls.

Utilization of full burning depth of the tile — typical of American Arch design — means maximum service life.

Air-cooling of the castings is provided by air lanes formed by the use of spacer castings and an outer steel casing plate.

Insulation blocks or blankets are held against face of tile by specially designed retaining bars, avoiding use of bolts or attachments that penetrate the insulation. A hard finish cement is applied between the bars, producing a neat, smooth exterior surface.

Each section of tile and insulation has its own unit-support castings.

This minimizes maintenance expense, because replacements of tile can be made in any section without disturbing adjacent sections. Rebuilding of entire side walls is unnecessary.

For any of your refractory problems you are invited to avail yourself of the recommendations of American Arch engineers.

COMPANY, Inc. INDUSTRIAL DEPARTMENT

60 East 42nd Street, New York, N. Y.

CLEVELAND • DENVER • DETROIT • LOS ANGELES • PHILADELPHIA

In 1924, Okolite insulation was first used by utilities and industrial plants. Since then, Okolite insulated cables have delivered outstanding performance consistently in a wide variety of exacting services.

24 YEARS OF SERVICE PROVE . . . .

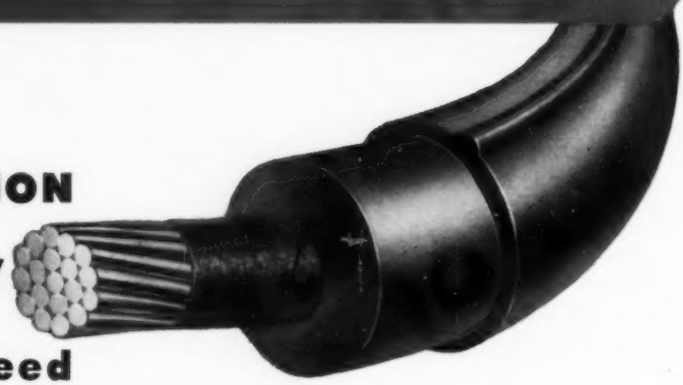
Hundreds of miles of Okolite-insulated cables used in high voltage service include insulated power cables operating at voltages as high as 35,000 between phases.

HIGH VOLTAGE APPLICATIONS PROVE . . . .

In addition to high voltage a-c proof tests made as a matter of routine, Okolite-insulated cables pass d-c proof tests also—tests made at 4 times the a-c values.

SUPER VOLTAGE D-C TESTS PROVE . . . .

OKOLITE INSULATION gives the internal stability all *Long-Lived* cables need



No single part of a cable affects its life more certainly than does its insulation. No matter how a cable is outwardly protected, trouble can develop internally if the insulating medium loses stability, deteriorates in electrical values, absorbs moisture.

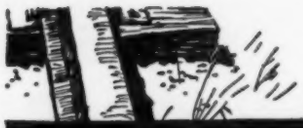
Not only does Okolite possess stable electrical characteristics plus moisture and ozone resistance but its heat resistance has been firmly established at 75 degrees C. conductor temperature under all kinds of service conditions.

Okonite's patented strip insulating method insures uniform wall thickness — an essential in high voltage cables. For details including Okolite advantages over lead-covered as well as ordinary rubber-insulated cables, write for Bulletin IS-1035, addressing The Okonite Company, Passaic, New Jersey.

7072

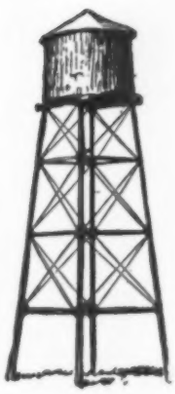
OKONITE SINCE 1878 **insulated wires and cables**

THE BEST CABLE IS YOUR BEST POLICY



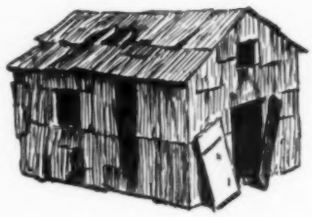
HOW MUCH PRESSURE IS PUT

on SCRAP-COLLECTIONS in your plant?



Scrap collections warrant determined action by top-level management, because output of virtually everything from adding machines to zephyr cloth is jeopardized by the continuing acute scrap shortage.

Take a good look around your plant . . . comb your entire property for broken, worn-out or obsolete machines . . . discarded line shafting . . . unusable girders . . . old chain . . . every sort of scrap metal.



Consult your local scrap dealer for advice on types, grades and sizes.

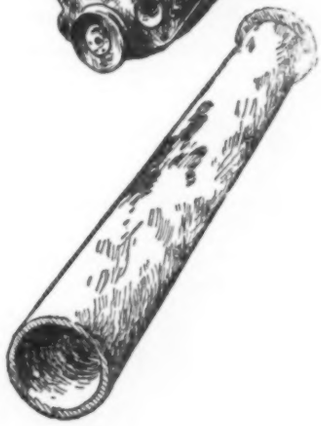
The amount of steel available depends upon the tonnage of scrap turned in. Everyone is affected by the scrap situation, and now is the time for each individual to get every available pound of scrap back to the mills.

★

MORE SCRAP—MORE STEEL

Move your scrap to the mills

SELL IT—SHIP IT—MOVE IT NOW!



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TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

Why do "Buffalo" FANS handle the *BIG* Jobs Better?

FANS by "Buffalo"

A "Buffalo" Fan to be installed in a large processing plant

It's easy to see that they DO — check the preferences of consulting and industrial engineers on the BIG jobs all over the continent, and you find "Buffalo" the outstanding flrst choice.
As to WHY "Buffalo" Fans are preferred, there are three good reasons:

1. **"Buffalo" builds "heavy-duty" fans for industry; light-weight construction is not part of our line.**
2. **"Buffalo" Sales Representatives are graduate engineers, with years of factory training before their selling careers start. They KNOW Fans, and your industrial application problems.**
3. **The seventy-year old "Buffalo" organization has specialized for more than fifty years in industrial fan applications.**

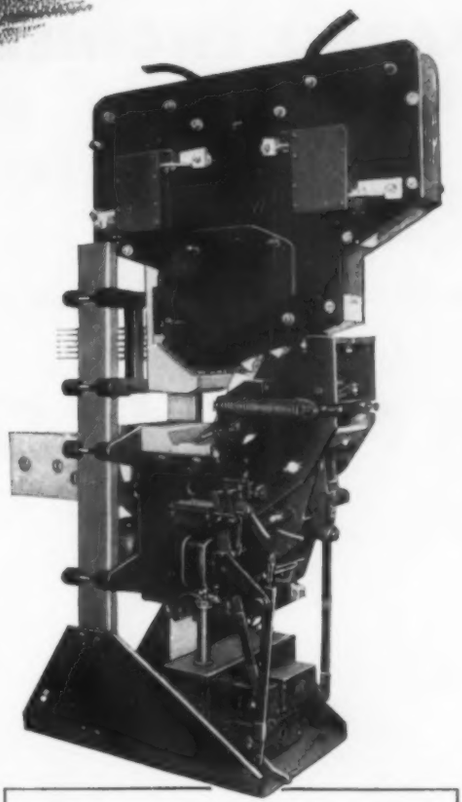
And, of course, there's a fourth reason which is important on big fans — that's efficiency — which means less horsepower to do the job.
When you specify "Buffalo" you're getting the best. Sales Representatives in all principal cities.

EQUIPMENT FOR

- ★ VENTILATING
- ★ HEATING
- ★ COMFORT COOLING
- ★ PROCESS COOLING
- ★ AIR TEMPERING
- ★ AIR WASHING
- ★ EXHAUSTING
- ★ BLOWING
- ★ FORCED DRAFT
- ★ INDUCED DRAFT
- ★ PRESSURE BLOWING
- ★ CLEANING
- ★ DRYING

BUFFALO FORGE COMPANY

173 Mortimer Street - Buffalo, New York
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.



Electrical disturbances can't spread trouble with this *more dependable, better built* breaker on the job!

• Short circuits and extremely heavy overcurrents don't have a chance to ruin your essential generators, motors, rectifiers, and connected production equipment—when your electrical distribution system is protected by proper application of I-T-E Type MT Automatic Reclosing Circuit Breakers.

The MT was specially developed by I-T-E—*Switchgear Specialists*—for interrupting extremely heavy direct currents. It breaks a circuit in .028 seconds (about $1\frac{3}{4}$ cycles on a 60 cycle basis) at 25% to 100% of interrupting capacity. I-T-E's *Rate-of-Current-Rise* Trip anticipates extremely heavy currents—distinguishes between a useful load of high value and a dangerous fault current—and trips the breaker before the danger peak is reached. Shorts and overcurrents are cleared instantly, dependably, before they have a chance to cost you money.

And with the MT breaker, you get an exclusive I-T-E "extra"—*better design* to give you the benefits of manufacturing savings which, in turn, allow higher-quality refinements *at no extra cost*.

Complete details on the I-T-E Type MT Air Circuit Breaker (including Automatic Reclosing Applications) are contained in illustrated catalog 2202. Send for your copy.

TYPE MT — for pedestal mounting. Single pole, electrically operated. Application: 250 and 750 Volts. Interrupting rating is 150,000 Amp. in continuous ratings 2000 and 4000; 250,000 Amp. in continuous ratings 6000 and above.

ARC EXTINCTION IN THE MT AIR BREAKER

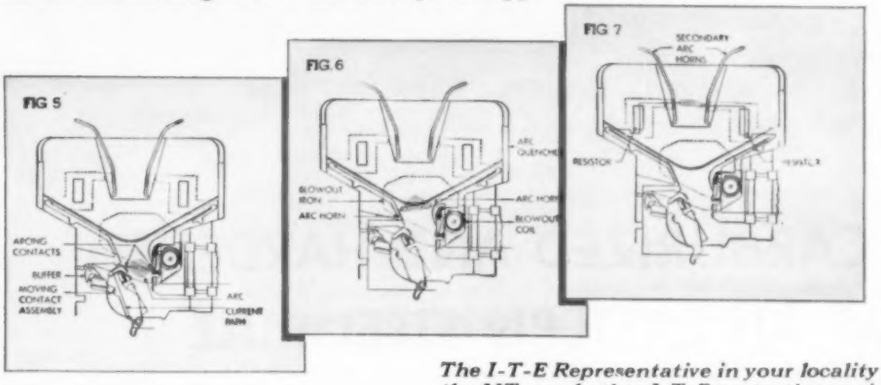


FIG. 5 First stage in circuit interruption: Arc drawn between arcing contacts; blow-out coil in circuit.

FIG. 6 Second stage: Arc transferred to arc horns.

FIG. 7 Final stage: Arc transferred to secondary arc horns; resistors in circuit.

The I-T-E Representative in your locality will be glad to advise you on applying the MT—and other I-T-E protective equipment—to your electrical distribution system. Use his services without obligation.

I-T-E

R&IE

*

MILL TYPE SWITCHGEAR

The Leader In Technical Excellence

I-T-E CIRCUIT BREAKER CO., 19th & HAMILTON STS., PHILA. 30, PA. — 31 OFFICES IN THE UNITED STATES
In Canada, EASTERN POWER DEVICES, Ltd., TORONTO

SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • AUTOMATIC RECLOSING CIRCUIT BREAKERS • HIGH SPEED CIRCUIT BREAKERS

*FOR POWER SWITCHING EQUIPMENT, REFER TO RAILWAY AND INDUSTRIAL ENGINEERING CO., AN I-T-E SUBSIDIARY

BADALL ENGINEERING & MANUFACTURING CO.

Mill Equipment

239-241 DOUGLAS STREET • SHEFFIELD 6671 • HAMMOND, INDIANA

LONG LIFE EQUIPMENT

TABLE ROLLS
PINCH ROLLS
ROLL SHELLS

COILERS
FLATTENERS
GUIDE ROLLS

A PARTIAL SHIPMENT

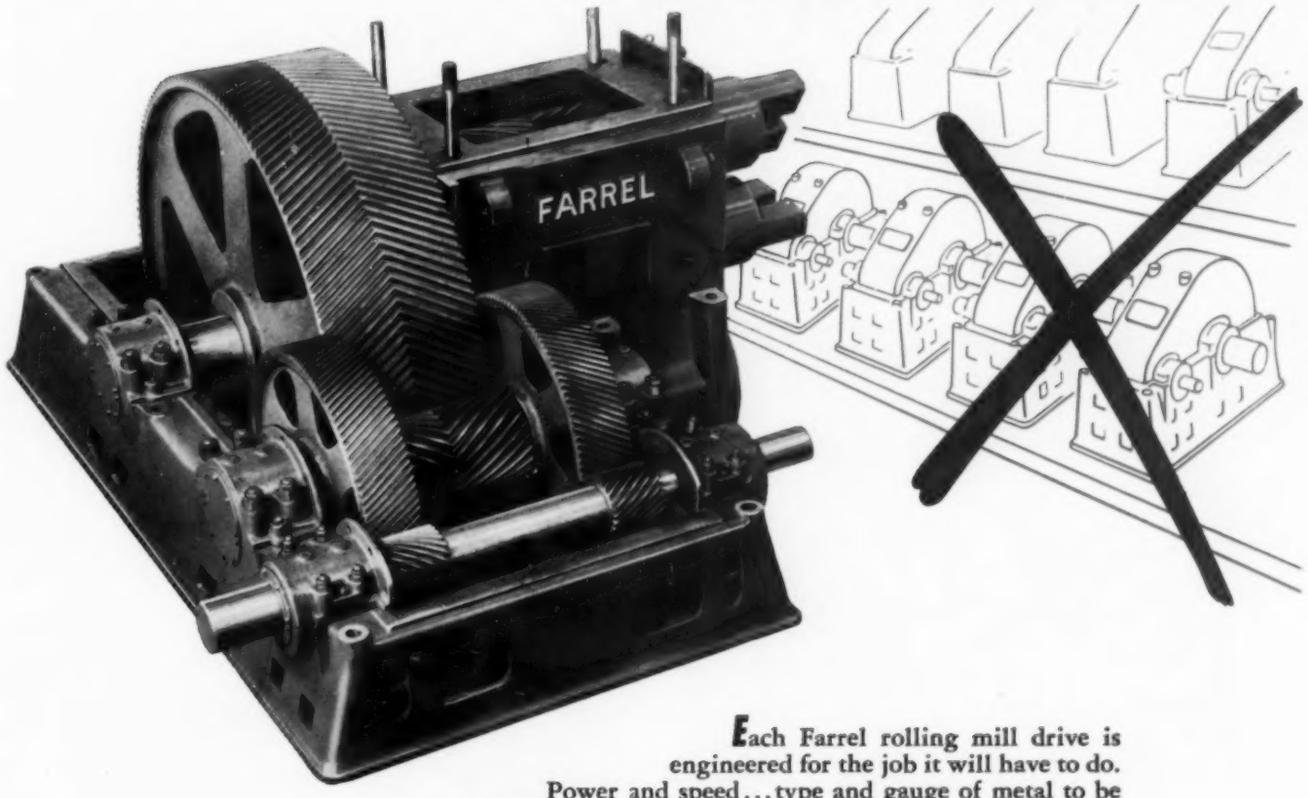
50 TUBULAR CARBURIZED AND HARDENED ROLLS FOR AN EASTERN STEEL MILL

Long Life - At Least 25 Years

(WE HAVE RECORD OF 12 YRS. LIFE)

Send Us Your Prints for a Prompt Estimate or Ask for More Information

why *Farrel* rolling mill drives never come "off the shelf"



Each Farrel rolling mill drive is engineered for the job it will have to do. Power and speed... type and gauge of metal to be rolled... process (hot or cold)... nature of load (continuous or intermittent)... type of drive motor... all are taken into account before the size, material and type of construction are specified. Such *specialized* drives can't be production-line made and stocked for future sale.

Housings are of cast steel, Meehanite or welded steel construction, with either double-walled or single-walled deep base, depending on requirements.

Gears are continuous tooth herringbone, the famous Farrel-Sykes *Gear with a Backbone;* single helical; or a combination of single and double helical as used in the drive illustrated on this page.

Bearings may be either babbitt-lined steel cartridges or any approved make of anti-friction bearing.

Depending on conditions or requirements, lubrication may be by dip-and-splash system, by built-in pump driven by one of the shafts, or by separate lubrication system.

When you need a mill drive built to fit your specific requirements, call on Farrel. Our engineers will be glad to discuss gear drive problems with you at any time without obligation.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN.

Plants: Ansonia and Derby, Conn.; Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Chicago, Los Angeles, Tulsa, Houston

FB-462

FARREL CENTENNIAL 1848 1948

Farrel-Birmingham

NORTH AMERICAN
OILTOGAS *Converter**

MAKES IT POSSIBLE
to burn No. 1, 2, or 3 Fuel Oil as a Gas in your present Gas Burners

Fig. 1 – Air Heater.

AVOID CRITICAL GAS SHORTAGES

Many industrial ovens, furnaces and boilers are fired with gas burners which do not lend themselves to the substitution of direct oil burners during the trying days of gas curtailments. For such applications North American offers the Oiltogas Converter.

Fig. 2 – Insert Assembly and Mixer.

PRODUCES CLEAN CARBON-FREE GAS FIRES

The principle of the Oiltogas Converter is to supply air at 700°F. to standard North American Aspirator (Gas-Air) Mixers. Into the mixer (through the displacement rod) is injected atomized oil. The hot air immediately vaporizes all of the finely atomized oil and carries the gaseous fuel thus generated to any number of burners.

The air heater shown in Figure 1 is direct oil-fired and is entirely automatic in operation and includes flame safety devices. The amount of fire at the furnace or oven burners is controlled by valves in the hot air line leading to the mixers.

Because of the high air temperatures used and the excellent atomization of the fuel, it is found that even on #3 catalytic fuel oil no carbon or condensate is formed in the piping or burner manifolds. This eliminates the necessity for installing condensate return piping and for periodic cleaning.

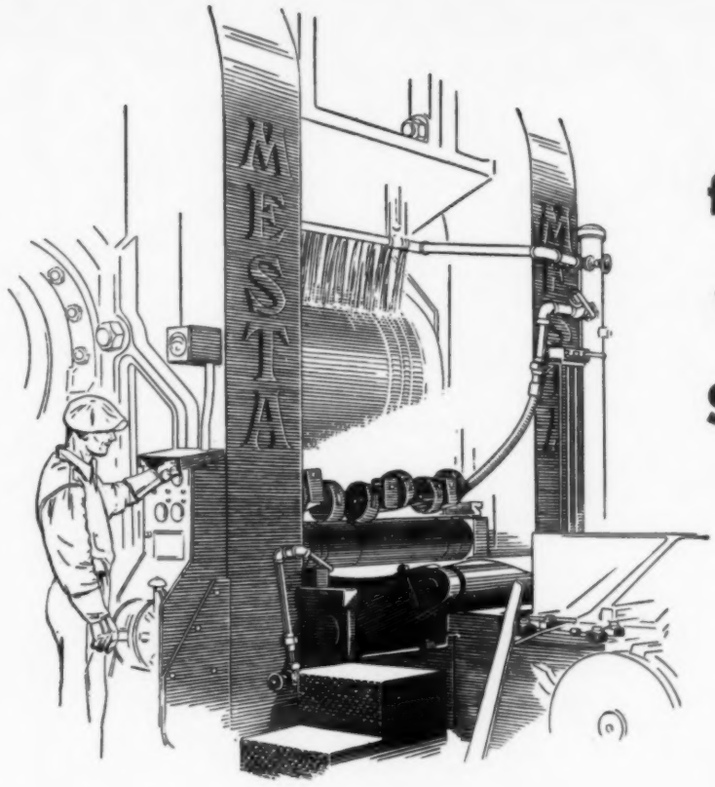
*A combination of Standard Combustion Equipment, backed by 30 years of Dependable Service

THE NORTH AMERICAN MANUFACTURING COMPANY

MANUFACTURERS OF INDUSTRIAL FUEL BURNING EQUIPMENT

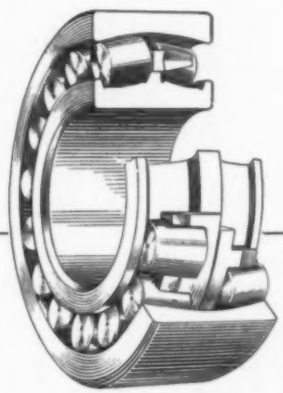
BRANCH OFFICES WITH FIELD ENGINEERS IN PRINCIPAL CITIES

CLEVELAND 5, OHIO



Efficient operation of looper rolls that control the slack between stands of 40" Mesta Tandem Mill is assured by Torrington Spherical Roller Bearings.

Longer Life for Looper Rolls with Torrington Spherical Roller Bearings



. . . looper rolls in Mesta 40" Tandem Mill equipped with Spherical Roller Bearings for smooth operation and minimum maintenance attention.

TO PROVIDE smooth operation at high speeds and eliminate lateral play of the looper rolls of the Mesta 40" Tandem Mill, Torrington Spherical Roller Bearings are used.

These self-aligning bearings assure proper alignment of shafts and compensate for deflections in operation. They carry combined radial and thrust loads efficiently, reducing wear to a minimum and assuring long service life. These are typical of the benefits gained by the use of Torrington Spherical Roller Bearings in many other steel mill applications – screw downs, gear trains, table rolls, take-up reels, pinion stands and other auxiliary equipment.

Torrington Bearing performance is backed by years of specialized experience in the design, manufacture and application of anti-friction bearings for exacting steel mill requirements. Call on Torrington's engineers for assistance in selecting and applying anti-friction bearings and for close follow-up service. Call or write the nearest Torrington office.

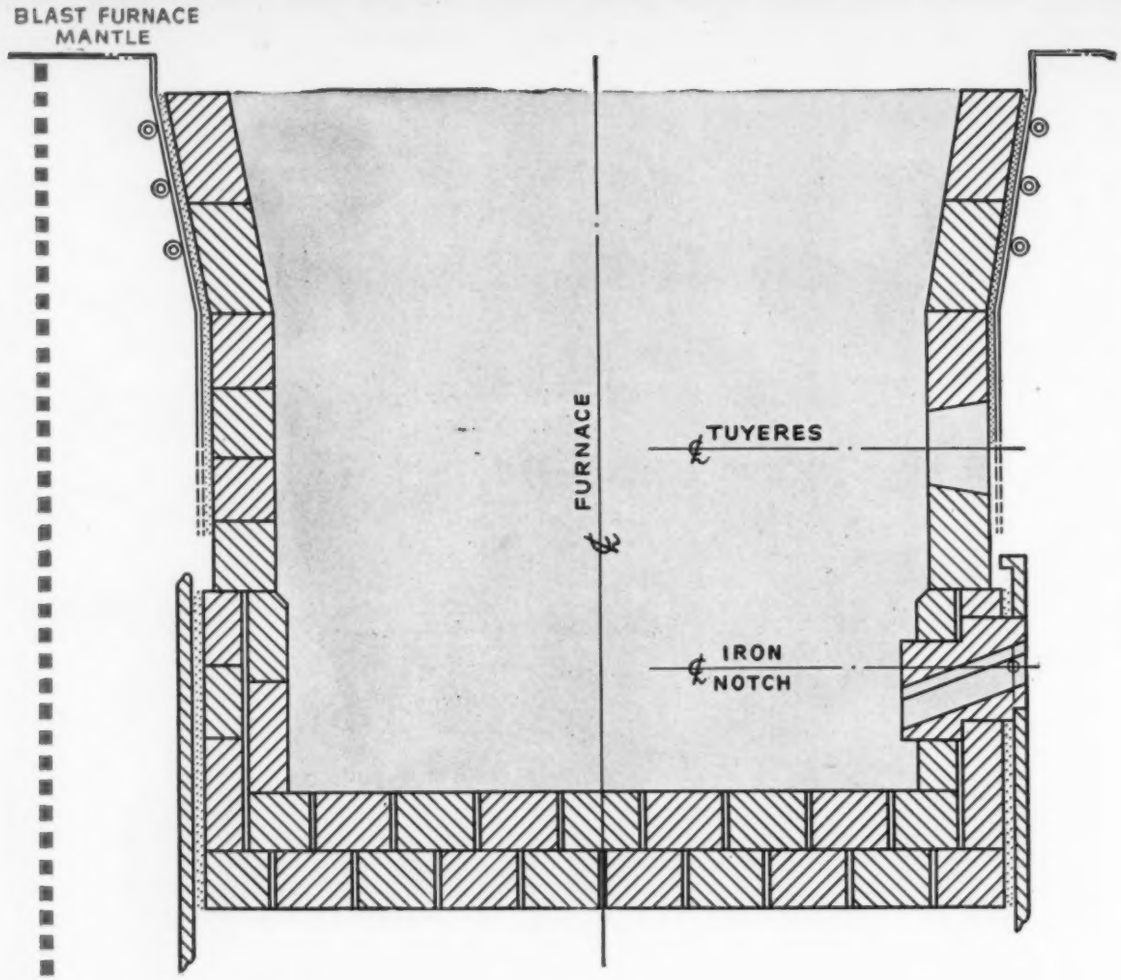
THE TORRINGTON COMPANY

South Bend 21, Ind. • Torrington, Conn.

District Offices and Distributors in Principal Cities

TORRINGTON *SPHERICAL ROLLER* **BEARINGS**

SPHERICAL ROLLER · TAPERED ROLLER · STRAIGHT ROLLER · NEEDLE · BALL · NEEDLE ROLLERS



Line it up to the mantle... with "National" Carbon

"National" carbon blocks have become the standard material for blast-furnace linings, for iron notches and cinder notches. And now, for real economy and efficiency, the trend in design takes the carbon-block lining up to the mantle.

Here are the reasons:

1. "National" carbon blocks last indefinitely. They have no melting point . . . are highly resistant to slag attack and thermal shock . . . are not wet by molten metal . . . have low thermal expansion . . . and maintain their mechanical strength at high temperatures.

2. "National" carbon blocks are easy to install. One carbon block takes the place of from 50 to 1000 nine-inch firebrick, depending on the size of the block. This means fewer joints, sounder joints, faster installation, and lower cost.

For more information on the use of "National" carbon blocks in blast furnaces, write to National Carbon Company, Inc., Dept. IS.

These products sold in Canada by Canadian National Carbon Company Limited

The term "National" is a registered trade-mark of

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

30 East 42nd Street, New York 17, N.Y.

Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

STEEL SCRAP IS URGENTLY NEEDED. BE SURE TO TURN YOURS IN!

Personnel News . . . .

Charles P. Hammond has been appointed superintendent of mills of the Rotary Electric Steel Company, Detroit, Michigan. He formerly was superintendent of mills for 15 years with Atlas Steels, Ltd., Welland, Ontario, and prior to that time was connected with United Alloy, Canton, Ohio, and Crucible Steel Company of America. Mr. Hammond's long experience will prove valuable to Rotary in their expansion program, which includes the installation of a 36-in. blooming mill, soaking pits, two additional electric furnaces and additions to bar rolling facilities.

Russell Massey was named superintendent of rolling mills for Atlas Steels, Ltd. Mr. Massey joined the Atlas organization in September 1941, as supervisor of the 26-in. and 22-in. mills, a position he has held since that time. Born in the United States, Mr. Massey entered the steel business in 1932 with the Weirton Steel Company, Weirton, West Virginia, holding various positions in their blooming, structural, strip and rail mills.

Allyn E. Harper was named chief plant engineer of Oliver Iron and Steel Corporation. Mr. Harper was formerly plant engineer of General Cable Corporation, St. Louis, Missouri. Graduated in architectural engineering from Bradley Polytechnic Institute, Peoria, Illinois, Mr. Harper was first associated with L. Eugene Robinson as a designer of industrial plants. He later was engaged in various engineering capacities with Allis-Chalmers Manufacturing Company, and Central Illinois Public Service Company, and was vice president and chief engineer of the Coal Carbonizing Company, St. Louis. More recently he was general superintendent of F. H. McGraw Company, and completed the engineering and installation of the equipment for the Lincoln and Mercury assembly plant in St. Louis.

Benjamin F. Fairless, president of United States Steel Corporation, and **John G. Munson,** vice president of United States Steel Corporation of Delaware in charge of raw materials, left November 5 for Rio de Janeiro for the purpose of inspecting certain ore deposits in South America, particularly in Brazil and Venezuela.

Promptly after V-J Day United States Steel resumed its practice of seeking to obtain full information about all known foreign deposits of iron ore which might be utilized in the future to supply the American steel industry. This exploration is undertaken in order to supplement and increase the life of reserves of iron ore in Minnesota and elsewhere in the United States.

For some time past, United States Steel has been carrying on extensive exploratory drilling in districts south of the Orinoco River in Venezuela where known iron ore deposits of considerable magnitude exist, and has acquired mining concessions in these districts from the government. At this time no definite plans have been formulated for actual development of the properties in Venezuela covered by these concessions.

Louis E. Feisner has been appointed superintendent of the new strip mill being erected by the Newport Rolling Mill division, International Detrola Corporation, Newport, Kentucky. Mr. Feisner brings to his new position many years of hot and cold strip mill experience, having been associated with Wheeling Steel Corporation, Jones and Laughlin Steel Corporation, United Engineering and Foundry Company, Mesta Machine Company, and recently Braeburn Alloy Steel Corporation.

W. Randall Compton, assistant to **Ben Moreell,** president and chairman of the board of Jones and Laughlin Steel Corporation, has been awarded the "Certificate of Merit" by the President's Board for exceptionally meritorious conduct in the performance of outstanding services to the United States during World War II while attached to the Office of the General Counsel, Department of the Navy, from June 1941 to May 1947.

G. B. Davis was promoted from assistant sales manager to sales manager of Baker-Raulang Company, Cleveland, Ohio. Mr. Davis was born in Jackson, Michigan, and graduated from Hillsdale (Michigan) College where he was prominent in athletics and other scholastic activities. He became associated with Baker-Raulang Company in 1935 and joined the sales staff of Baker Industrial Truck division two years later.

F. R. Fishback, chairman of the board of Electric Controller and Manufacturing Company, retired December 1, 1948. Mr. Fishback came to Electric Controller in 1905 and in 1925 was elected president, a post he held until 1943 when he became board chairman.

CHARLES P. HAMMOND

RUSSELL MASSEY

ALLYN E. HARPER

F. R. FISHBACK

DE LAVAL GEAR REDUCERS
in STOCK
CRATED FOR
IMMEDIATE
SHIPMENT

WG-22

These popular units are assembled, crated and ready for immediate shipment.

Reducer	*Ratio*	*Probable *HP Motor*	*Reducer*	*Ratio*	*Probable *HP Motor*
BW400	9⅔	5	BW600	11⅔	10
BW400	19½	3	BW600	19½	7.5
BW400	25	2	BW600	25	5
BW400	40	1.5	BW600	40	3
BW500	11⅔	7.5	BW700	9⅔	15
BW500	19½	5	BW700	19½	10
BW500	25	3	BW700	25	7.5
BW500	60	1.5	BW700	40	5

** Based on 1750 rpm—A.G.M.A. Class 1 Service. For other rpm's or Service refer to De Laval rating tables.*

Other sizes and ratios, in both single and double reductions, and in vertical and horizontal drives, also can be furnished promptly.

PHONE FOR QUICK SERVICE TO THESE
DE LAVAL SALES OFFICES

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Boston, Mass. Liberty 2-5993
Charlotte, N. C. Charlotte 3-7549
Chicago, Ill. Harrison 3290
Cincinnati, Ohio Dunbar 4654
Cleveland, Ohio Henderson 7500
Denver, Colo. Main 0697
Detroit, Mich. Madison 0950
Houston, Texas Wentworth 3-2823
Indianapolis, Ind. Albert 9433
Kansas City, Mo. Harrison 0744
Los Angeles, Calif. Michigan 6003
New Haven, Conn. New Haven 8-3459
New Orleans, La. Raymond 0228
New York, N. Y. Bowling Green 9-1550
Philadelphia, Pa. Rittenhouse 6-8086
Pittsburgh, Pa. Court 5400
Rochester, N. Y. Stone 6950
St. Paul, Minn. Garfield 1836
Salt Lake City, Utah Salt Lake City 3-7933
San Francisco, Calif. Sutter 3426
Seattle, Wash. Elliott 3437
Tulsa, Okla. Tulsa 5-2151
Washington, D. C. National 9238

DE LAVAL STEAM TURBINE CO.
TRENTON 2, NEW JERSEY

R. G. Widdows, president since 1943, will continue in that post and will be executive officer of the company. Succeeding Mr. Fishback as a member of the board of directors is **A. C. Dyer,** vice president and sales manager.

A. C. DYER

Dr. H. P. Munger, for nineteen years associated with the steel industry in product development and production work, has joined the staff of Battelle Institute, Columbus, Ohio. At Battelle he will be engaged in research in chemical engineering.

Carl L. Radway has been appointed division superintendent, cold rolling mills at the Cuyahoga works, Cleveland, Ohio, of American Steel and Wire Company, U. S. Steel subsidiary. He succeeds **C. M. Sackerson,** deceased. Mr. Radway is a native Clevelander, having been born there in October, 1893. He attended Case Institute of Technology before joining the American Steel and Wire Company in 1912 as a gas washer at Central Furnaces in Cleveland. He left the company in November, 1913, and upon rejoining American Steel and Wire in March, 1916, he was transferred to the Cuyahoga works as foreman in the flat cleaning department. All of his experience since that time has been at Cuyahoga works where since January, 1946, he has been department superintendent, production planning.

Orville F. Figley has been appointed manager, Chicago district, of the United States Steel Supply Company. With the company for over 30 years, Mr. Figley has served exclusively as sales manager for the Chicago district for the past two years. His headquarters will be the company's district office and warehouse at 1319 Wabansia avenue. Named as assistant district managers are **Frederick L. Bruckner** and **Arthur W. Johnson. Howard Heiser** has been appointed office manager.

Herbert E. Johnson has been appointed superintendent of transportation and labor for the Youngstown district of Youngstown Sheet and Tube Company. Mr. Johnson, a native of Ashtabula, Ohio, began railroading as a messenger and clerk for the New York Central Railroad in 1918, became yard clerk in 1919; foreman of yard clerks in 1923; yardmaster in 1924 and was transferred to Youngstown as general yardmaster in 1942. Early in 1944 Mr. Johnson joined Youngstown

Sheet and Tube Company as superintendent of transportation and labor at its Brier Hill works, and held that position until his recent appointment.

Norman Joyce Kilmer was appointed sales representative for Ohio Electric Manufacturing Company's lifting magnets in the Pittsburgh and Wheeling area. Mr. Kilmer's offices are located in the Frick Building, Pittsburgh, Pennsylvania.

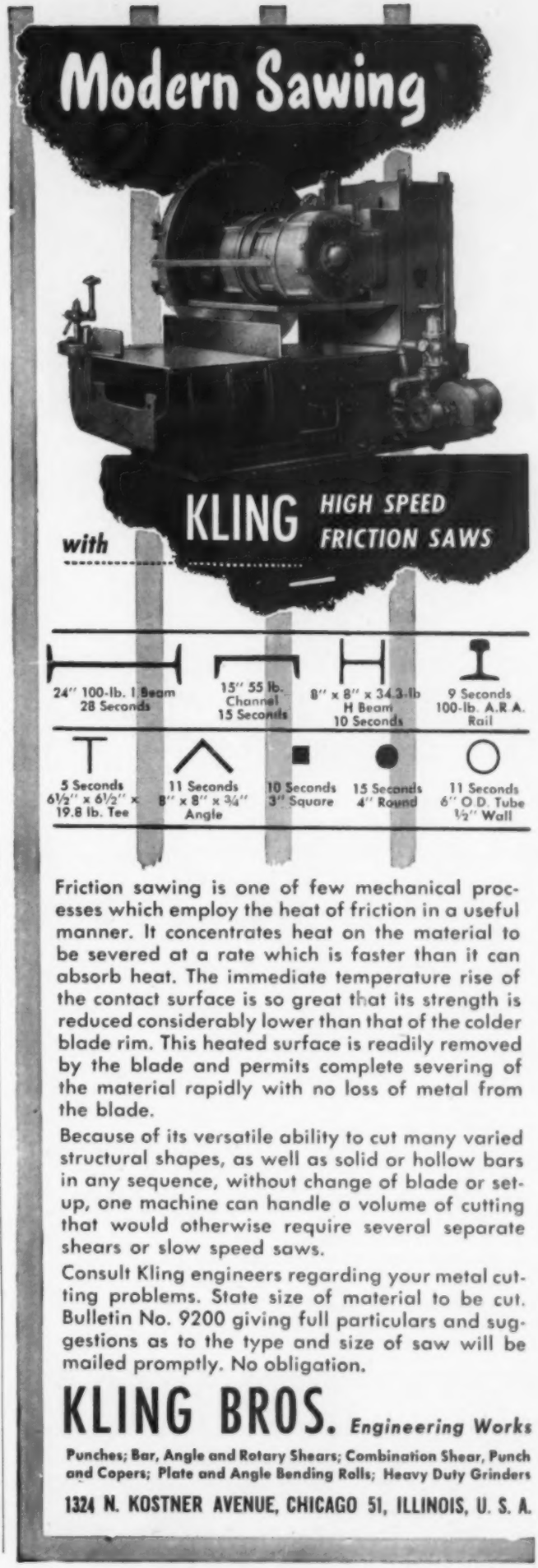
A. Edward Jennens has been recently appointed district manager for Cardox Corporation with headquarters in the Stephenson Building, Detroit, Michigan. Mr. Jennens until recently had been connected with Smith, Hinchman, Grylls, Architects, of Detroit. He is a life-time resident of Detroit and a graduate of Michigan State University. He succeeds **Albert C. Wallich,** who has retired from the Cardox organization to enter business for himself.

C. P. Cryer has been placed in charge of the newly established branch office of the machinery division of Dravo Corporation in Baltimore, Maryland. The Baltimore office represents De Laval Steam Turbine Company, Askania Regulator Company, and Davis Engineering Company. In addition, it handles Dravo "Counterflo" heaters, Dravo crane cab coolers, engineering construction of power plants and fabricated power piping. Mr. Cryer is a graduate in mechanical engineering of Swarthmore College, served three years in the Navy as an engineering officer, and was with the Philadelphia, Pennsylvania, office of this firm. His headquarters in Baltimore are at 100 North Eutaw Street.

C. H. Arnold, Jr., was recently named president of Railroad Siding Construction Company, Clark Building, Pittsburgh, Pennsylvania. Mr. Arnold has been engaged in the pipe cleaning and industrial pipe maintenance field for the past twelve years. He is also president of Eastern Pipe Maintenance Company. The new firm of Railroad Siding Construction Company will engage in construction, maintenance and rehabilitation of industrial railways.

C. H. ARNOLD, JR.

William J. Hall was appointed production manager of the Ivanhoe division of Reliance Electric and Engineering Company. A Clevelander by birth, Mr. Hall first joined Reliance back in 1935 as a dispatcher in the production department. He has been night superin-


Modern Sawing
with
KLING HIGH SPEED FRICTION SAWS
24" 100-lb. I Beam 28 Seconds
15" 55 lb. Channel 15 Seconds
8" x 8" x 34.3-lb H Beam 10 Seconds
9 Seconds 100-lb. A.R.A. Rail
5 Seconds 6½" x 6½" x 19.8 lb. Tee
11 Seconds 8" x 8" x ¾" Angle
10 Seconds 3" Square
15 Seconds 4" Round
11 Seconds 6" O.D. Tube ½" Wall

Friction sawing is one of few mechanical processes which employ the heat of friction in a useful manner. It concentrates heat on the material to be severed at a rate which is faster than it can absorb heat. The immediate temperature rise of the contact surface is so great that its strength is reduced considerably lower than that of the colder blade rim. This heated surface is readily removed by the blade and permits complete severing of the material rapidly with no loss of metal from the blade.

Because of its versatile ability to cut many varied structural shapes, as well as solid or hollow bars in any sequence, without change of blade or set-up, one machine can handle a volume of cutting that would otherwise require several separate shears or slow speed saws.

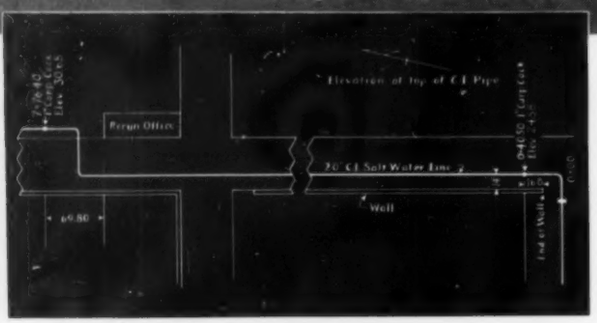
Consult Kling engineers regarding your metal cutting problems. State size of material to be cut. Bulletin No. 9200 giving full particulars and suggestions as to the type and size of saw will be mailed promptly. No obligation.

KLING BROS. *Engineering Works*

Punches; Bar, Angle and Rotary Shears; Combination Shear, Punch and Copers; Plate and Angle Bending Rolls; Heavy Duty Grinders

1324 N. KOSTNER AVENUE, CHICAGO 51, ILLINOIS, U. S. A.

A SURVEY WAS CONDUCTED
...A Report Was Made



The following are excerpts taken from an actual report of an engineering survey made by the Pittsburgh Pipe Cleaner Company for an Eastern refinery.

The test of this 20" salt water line indicated a Williams & Hazen coefficient of "C" = 58, which is sufficiently low to reveal a serious need of rehabilitation. The present delivery of this line is 8.34 M.G.D. If rehabilitated, the Williams & Hazen "C" value would conservatively be raised to 120, with an increase in flow under existing pressure conditions to 17 M.G.D.

Result of Tests:

Date of test	September 18, 1948
Length of main Sta 0 + 40.50 to 11 + 07	1066′
Equivalent length of two 90° bends	100′
Total equivalent length tested	1166′
Flow in line during test	8.34 M.G.D.
Loss of head in 1166′	28′
Williams & Hazen formula "C" =	58
Calipered diameter:	
Sta 0 + 40.5	19 3/16″
Apparent thickness of incrustation	3/16″
Sta 11 + 07	19 7/16″
Apparent thickness of incrustation	5/16″
Velocity coefficients determined by traverse along diameter:	
Sta 0 + 40.5	.80
Sta 11 + 07	.82

PITTSBURGH PIPE CLEANER CO.
133 Dahlem St., Pittsburgh 6, Pa.
BALTIMORE BIRMINGHAM BOSTON BRADENTON, FLORIDA
BUFFALO CHARLOTTE CHICAGO CINCINNATI DETROIT
HOUSTON NEW YORK PHILADELPHIA ST. LOUIS

tendent of the Ivanhoe division for the past two years. At one period during his service in the Reliance manufacturing organization, Hall attended Harvard Business

WILLIAM J. HALL

School, Cambridge, Massachusetts, where he took up special studies.

C. F. Seyler, formerly assistant chief engineer of Jones and Laughlin Steel Corporation, has been appointed manager of construction. In this new office, Mr. Seyler's responsibility will include field construction and installation of all facilities in the improvement program of the corporation and subsidiaries. Mr. Seyler has been with J & L since 1922. He started at Aliquippa works as design engineer and served at Aliquippa as assistant chief engineer and maintenance engineer until 1940, when he was appointed assistant chief engineer of plants. He was appointed assistant chief engineer for the entire corporation in July, 1948, and served in that capacity until his recent appointment as manager of construction.

D. L. Frawley has been elected chairman of the board of directors of Mackintosh-Hemphill Company. Mr. Frawley succeeds the late H. V. Blaxter, who died on October 30. Mr. Frawley, a director of Mackintosh-Hemphill Company for more than 16 years, has been associated with the company and its predecessor companies since 1918. Mr. Frawley is a director of Oliver Iron and Steel Corporation; Follansbee Steel Corpo-

FURNACE ENGINEERS, INC.
FURNACES
FOR THE
STEEL INDUSTRY
F.E.I.
1551 W. LIBERTY AVE. PITTSBURGH 26, PA.

ration; Pittsburgh Oil and Gas Company; Capital Airlines Corporation; Colonial Trust Company of Pittsburgh, and American Fruit Growers, Inc., Los Angeles, California. He is vice president and a director of Bareco Oil Company, Tulsa, Oklahoma, and of the Barnsdall Oil Company, New York.

James W. Dice, formerly with Westinghouse and more recently assistant sales manager of Sperry Products, announces the formation of a new sales and development organization to be known as J. W. Dice and Company. Headquarters are at Grand View-on-Hudson, New York.

Obituary

Myril L. Jacobs, 63, vice president of raw-material properties for the Bethlehem Steel Company, died November 13 in Trinidad, where he was making a tour of company properties. Mr. Jacobs was born in Weldbank, Pennsylvania. He attended Mercersburg Academy and Marietta College, and was graduated in 1910 from Lehigh University with a degree in mining engineering.

O. C. George, 74, Canonsburg, Pennsylvania, formerly chief draftsman at Fort Pitt Bridge Works, died November 15. Mr. George retired from his employment at Fort Pitt two years ago after serving the company for 45 years.

James Dyer Jones, aged 67, former chief engineer for Youngstown Sheet and Tube Company, died November 7 in New York City.

Mr. Jones, who left Youngstown Sheet and Tube Company four years ago to become a partner in H. A. Brassert and Company, New York, New York, served as chief engineer at the Youngstown Sheet and Tube Company from 1935 until he resigned in March, 1945. He was in charge of all company improvements during that time.

John Alfred Cox died suddenly at his home in Gadsden on October 16. At the time of his death, he was superintendent of the electrical department at

JOHN ALFRED COX

Republic Steel Corporation in Gadsden, Alabama. He had been employed continuously at that plant for 32 years and was for 10 years a superintendent.

SAFER, FASTER MARKING with the **SAFETY BOX TYPE HOLDER**

The Safety Box Type Holder for safe and efficient marking of hot or cold, flat, round or angular surfaces—is made of one piece of Safety steel with welded handle, for heavy duty service. Outer sleeve holds type holder at right angles to surface, assuring perfect impressions. Type is quickly and easily changed.

- NO MUSHROOMING
- NO SPALLING
- BETTER MARKING
- LONGER SERVICE LIFE

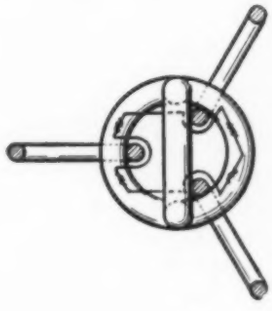
Write for Complete Data

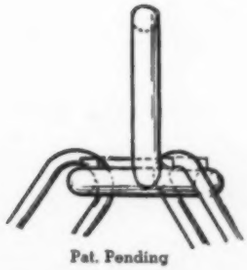
M.E. CUNNINGHAM CO.
SAFETY STEEL STAMPS

105 E. CARSON STREET PITTSBURGH 19, PA.

TRY THE BEST...

in magnet suspension chains





Pat. Pending

Reduce expense and lost time due to replacement of magnet suspension chains and periodic annealing.

***Try The Frictionless* suspension chains**

1. They last up to 3 times as long as old style suspensions.
2. They are made of heat-treated high alloy steel to eliminate periodic annealing.
3. Ring plate keeps chains separated by 120 degrees. No rubbing or twisting and keeps magnet level.
4. Each chain for 55 inch magnets is tested to 89,000 lbs.
5. Each chain for 65 inch magnets is tested to 115,000 lbs.

Write for prices. Prompt shipment from stock.

DOWNTOWN *Company*

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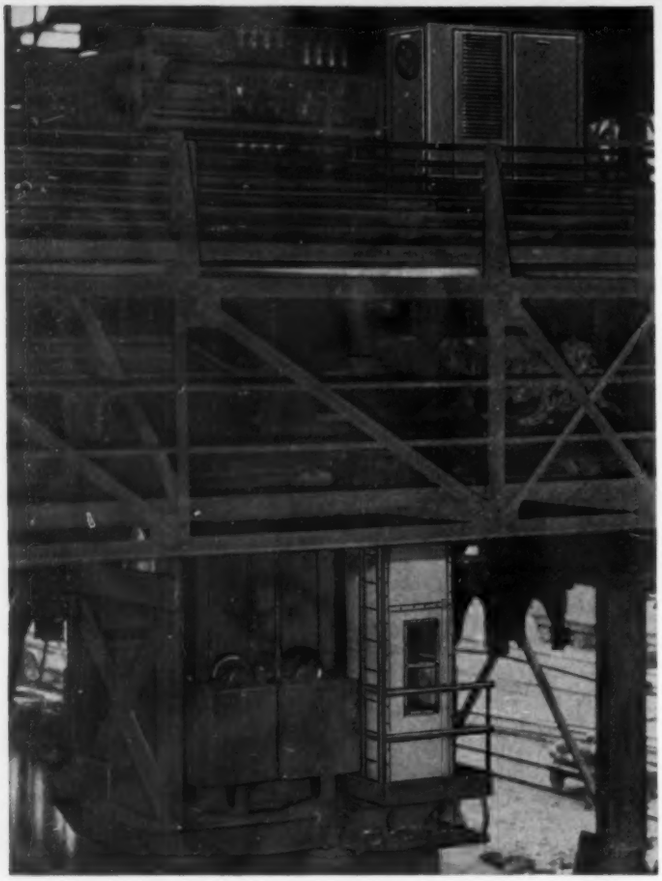

NEW Lintern Aire Rectifier

Saves Up to 30% Per Installation

Shown above is a typical soaking pit crane equipped with Lintern Aire-Rectifier. Costly air ducts are eliminated in this improved design. Note location of condenser unit (indicated by arrow) high on trolley away from direct radiant heat. The evaporator, or cooling blast coil, is located in the cab. The two units are connected with refrigerant lines.

These six advantages result: (1) Reduced engineering costs. (2) Big savings by elimination of expensive, efficiency-reducing air ducts. (3) Higher cooling efficiency in the cab. (4) Greater flexibility in location of all equipment. (5) Lengthened life of operating equipment because of protection from excessive radiant heat and greater accessibility for service. (6) Location of Aire-Rectifier on existing cranes without moving any equipment.

Ask for the four-page, fully illustrated Bulletin AC948.

THE LINTERN CORPORATION

54 Lincoln Avenue Berea, Ohio

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are not fussy...

IF you desire to avoid delays due to poor quality and poor deliveries, PLACE YOUR ORDERS WITH FALCON.

IF you are a discriminating buyer, one who requires excellence in quality, service and delivery, PLACE YOUR ORDERS WITH FALCON.

IF you expect flawless castings in record time, PLACE YOUR ORDERS WITH FALCON.

FALCON'S part in blast furnace and steel mill operations, since its establishment in 1890, has been to provide such specialized services on all non-ferrous casting needs.

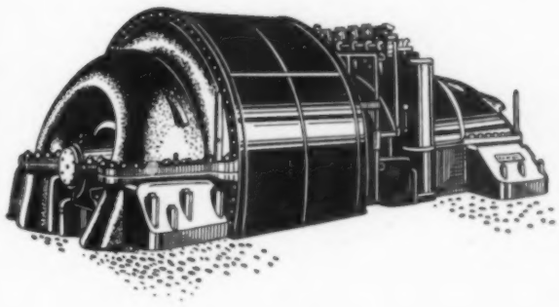
TELEPHONE COLLECT - 3-4355

FALCON BRONZE CO.

YOUNGSTOWN 3, OHIO

Established 1890 • Incorporated 1895

Filtered Air solves blade erosion problem on Turbo-Blowers



WHY should the life expectancy of impellers in turbo-blowers be limited to six, nine or eighteen months? The reason—when quantities of abrasive dust and dirt, such as found in unfiltered air, are permitted to enter a high speed, rotary blower, rapid wear and erosion of the impeller is certain to result.

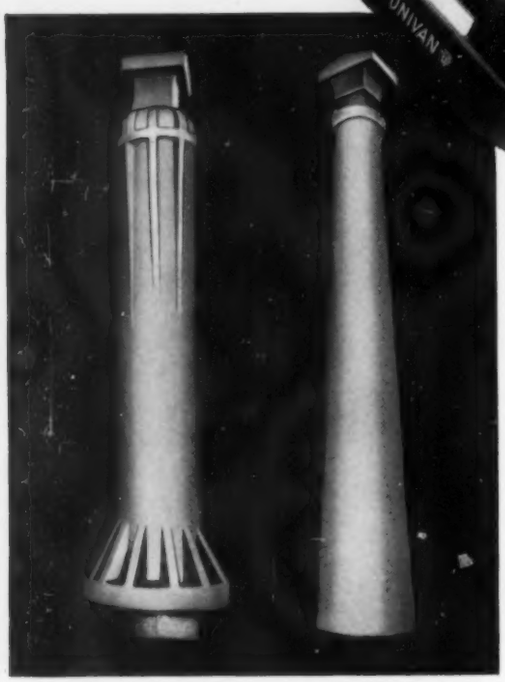
Installation of AAF Multi-Duty Air Filters at the blower intake has proven a practical solution to this problem. In one mill, where unfiltered air had completely ruined the impeller after 17,000 hours' operation, the replacement unit checked after 12,000 hours with Multi-Duty filtered air showed no trace of erosion.

The AAF Multi-Duty is an automatic self-cleaning air filter. Overlapping panel construction of the filter curtain combines positive self-cleaning and high efficiency air cleaning as integral functions of the operating cycle. Uniformly constant air supply is assured as operating resistance remains fixed when once established for a given dust concentration.

The Multi-Duty's record of prolonging impeller life, eliminating costly repairs and untimely shutdowns warrants your immediate investigation. For complete information contact your local AAF representative or write direct to:

AMERICAN AIR FILTER COMPANY, INC.
302 Central Avenue, Louisville 8, Ky.
In Canada: Darling Bros., Ltd., Montreal, P. Q.

AAF
AIR FILTERS
AND DUST CONTROL EQUIPMENT



UNION *Alloy Steel* PEELS

Except for the charge itself, no piece of unprotected metal is subjected to greater heat for a longer time than the peel. And, hot or cold, it must withstand severe shock and stresses as well. "Union" has developed for this tough service peels of heat and shock resistant alloys in designs that add months to their useful life . . . Glad to quote from your specifications on either rough or fully machined castings.

Bridge that Gap with UNIVAN

DOUBLE LIFE HEAD CHARGING BOXES

It's a short haul from scrap yard to furnace . . . no warming-up time to ease the shock on chilled charging boxes before they're slammed into steel-melting temperatures.

No wonder so many ordinary boxes crack under this strain, and soon become scrap themselves. No wonder so many production-minded open hearth men have changed over to UNIVAN—the improved charging boxes of shock-resisting nickel-vanadium steel with reinforced Double Life Head! They've proved to their own satisfaction that a faster charging job can be done, for a longer time at less cost per year . . . Your request for further details and prices will receive our immediate attention.

"UNIVAN"

UNION STEEL CASTINGS

DIVISION OF BLAW-KNOX CO., PITTSBURGH, PA.

Cinder Pots • Slag Pots • Coupling Boxes • Spindles • Gears • Bells and Hoppers • Ingot Cars • Charging Cars • Annealing Boxes and Bases

Let's take a LOOK at the inside of a WARE HI-LAG Renewable FUSE

Five Exclusive Features!

No. 1 Double Fibre Bridge Assembly increases strength 10 times. Maintains perfect alignment.

No. 2 Only one wrench needed to remove blown link and renew.

No. 3 Rugged simplicity. Only 3 parts to handle in renewing link.

No. 4 HI-LAG Link of one piece, uniform thickness, has large contact areas — wide body areas to insure dependable absorption of heat for time lag.

No. 5 Arched spring tension washers and heavy studded bolt, keeps links permanently tight. Reducing excessive heat and needless blows.

WARE HI-LAG FUSES have many exclusive features in design and construction which make them far superior in operation — much more economical in rendering longer fuse life and with unsurpassed safety insurance.

Try WARE HI-LAG FUSES NOW! Start enjoying uninterrupted production progress and new fuse economy with the World's Best and Coolest Operating Renewable Fuse.

Write for Fuse Booklet No. 4460 giving all features, sizes and details.

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MORGANITE POINTERS
on better brush performance —

No. 6- Staggering Brushes

Uniformity of color and freedom from grooving on a commutator surface are, among other factors, the result of correct staggering of brushes.

The surface film developed beneath the positive brush is not the same as that under the negative brush. For uniformity in commutator appearance, equalization of commutator wear, as well as certain advantages in respect to performance — brushes should be staggered by pairs of poles, one arm of positive polarity to track one arm of negative, the next pair staggered axially and so on.

For best results use Morganite grades. We invite your inquiry.

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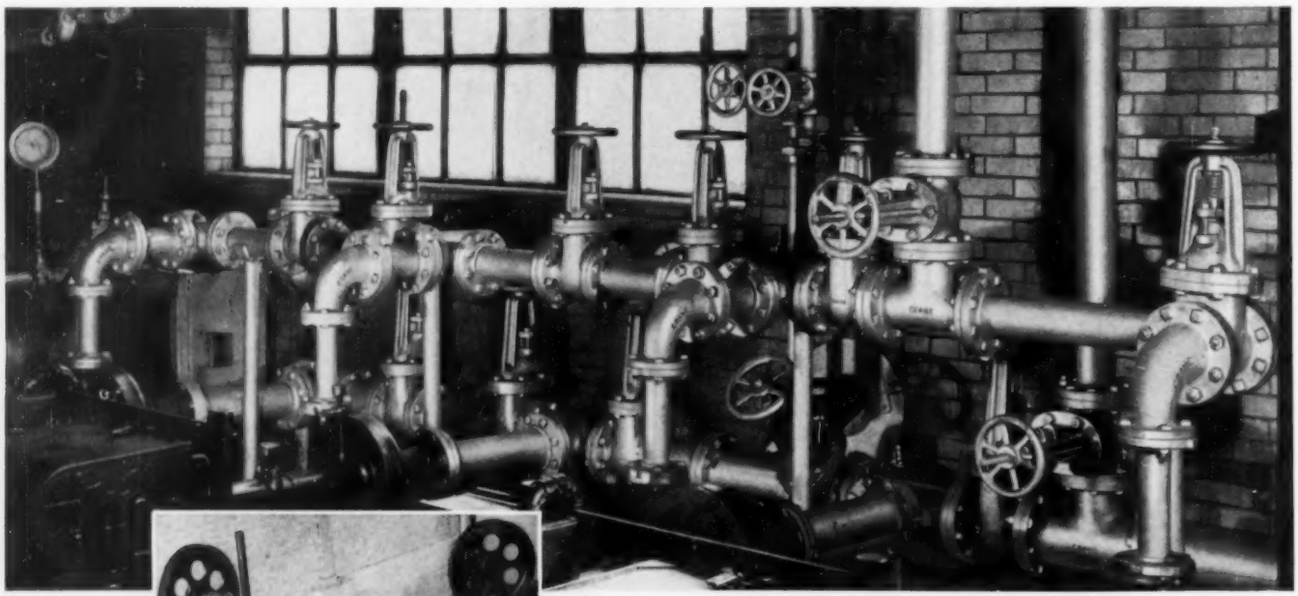
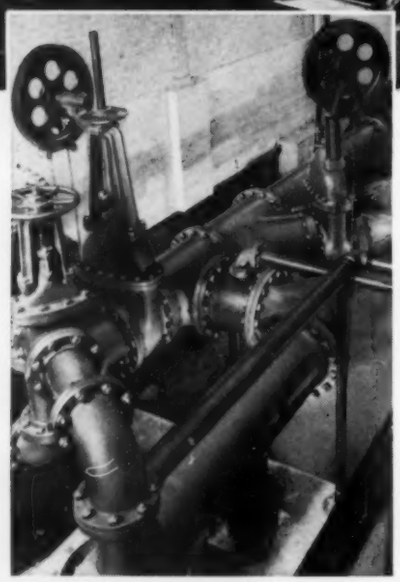
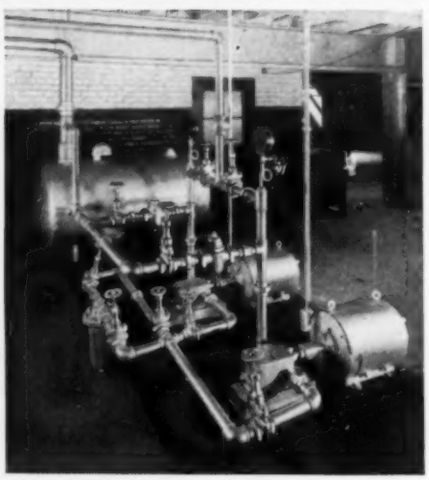




IN A COKE BY-PRODUCTS PLANT—*Crane valves, fittings, pipe and accessories on liquor circulating pumps for cooling coke oven gases.*

IN A ROD MILL—*Crane gear and chain wheel operated gate valves, check valves, flanged and screwed fittings in main water supply piping in pump house.*

IN A STEEL AND WIRE MILL—*Crane No. 488 Clamp Gate Valves in heating oil piping system provide quick opening for frequent inspection, easy cleanout.*



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VALVES
FITTINGS
PIPE

CRANE

PLUMBING
AND
HEATING

FOR EVERY PIPING SYSTEM

Steel Mill Boosts Quality and Output With Help of Micromax Pyrometers

How can a steel mill engineer invest his Company's thousands of pyrometer dollars, so as to get the greatest dividends from the millions invested in manufacturing equipment?

And how can he surely make his control systems help to the utmost in holding quality, cutting costs and raising output?

Following are some of the answers, taken from a mill which turns out a wide variety of products and where the right temperature control by means of Micromax instruments has proved its worth in many processes.

Continuous Tinning (See Fig. 1)

Uniform temperature in the tin pot helps to maintain uniform rate of deposit, minimum dross formation and maximum production.

Hot Dip Galvanizing (Fig. 2)

Here Micromax Electric Control throttles fuel to the burners. Accurate temperature control means uniform coating, lower consumption of zinc, less maintenance, and less "down time" for drossing.

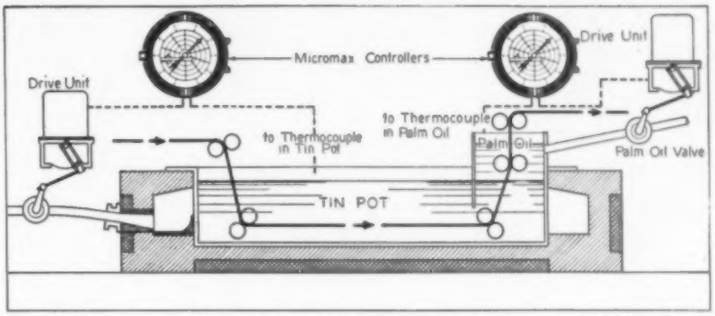

Figure 1. Continuous hot-dip tin pot.

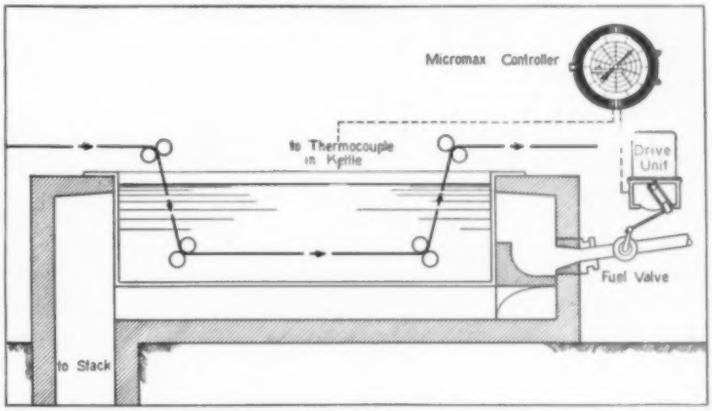

Figure 2. Galvanizing kettle, on continuous sheet line.

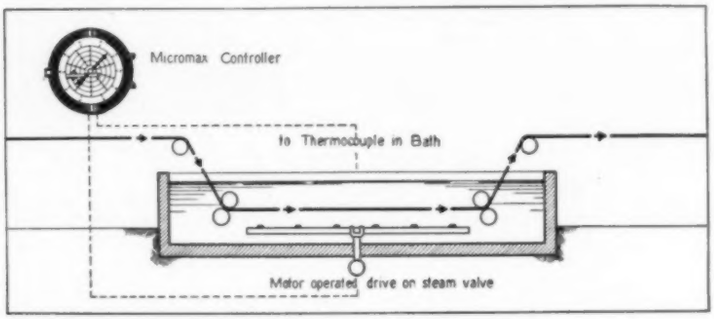

Figure 3. Steam-heated pickling baths.

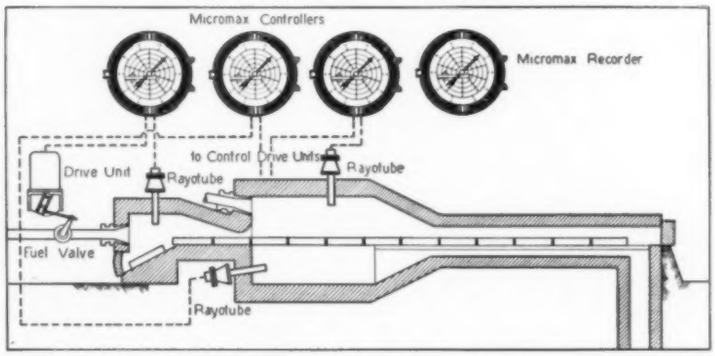

Figure 4. Slab heating furnace. A fourth Rayotube near the one shown in the lower zone detects slab temperature and reports it to the Pyrometer at top right.

Continuous Pickling Baths (Fig. 3)

Here the ability of Micromax to stay on the job continuously, and with low maintenance, helps to keep the process operating at top efficiency a maximum percentage of the time.

Slab Heating Furnace (Fig. 4)

This illustrates the application of Micromax Rayotube Pyrometers to a complex temperature control problem.

Complete temperature control helps the furnace to perform efficiently its functions of bringing the slabs back to rolling temperature, holding them at temperature until the mill is ready to receive them, and finally delivering the slabs at the right time properly conditioned for efficient rolling.

An L&N field engineer is always ready to discuss any temperature control problem with you. Or if a description of the equipment will meet your needs, we'll be glad to send catalogs on request. Address Leeds & Northrup Co., 4942 Stenton Avenue, Philadelphia 44, Pa.

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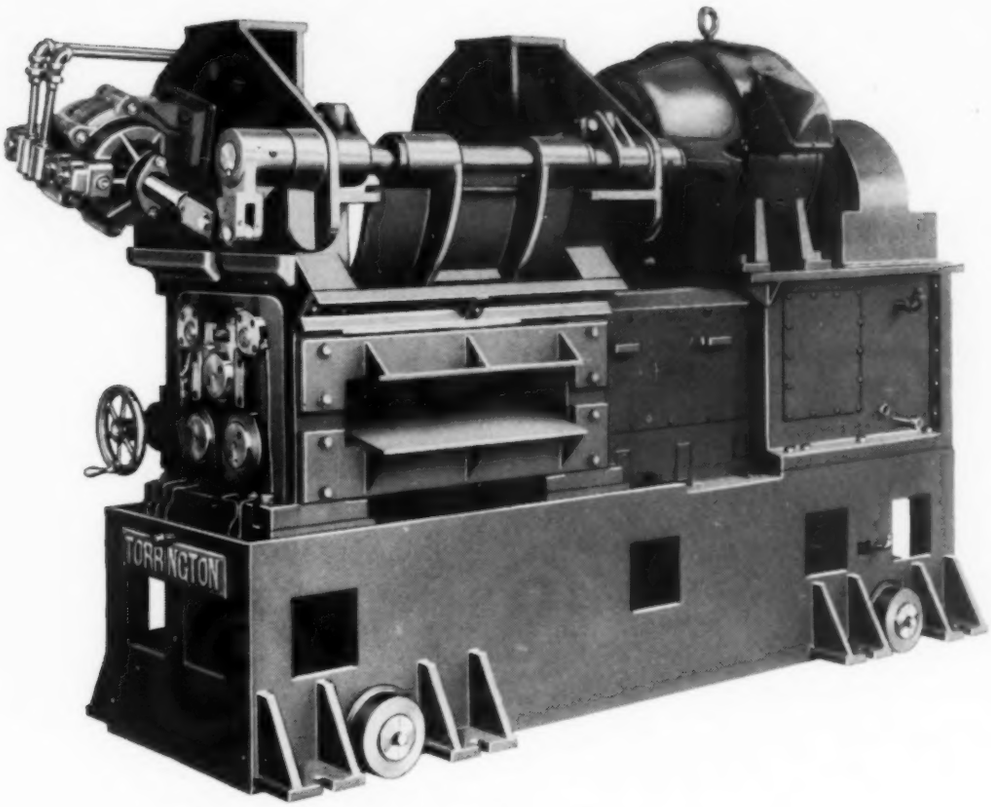

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Torrington Coilers are completely self-contained on a welded steel base, with the motor mounted above the pinion housing for compact installation. Three types of mounting are available: stationary for permanent location; and, where a non-working position is required, either a swinging mount or a sliding mount.

Among the features which make Torrington Coilers extremely popular in the metal mills are: their clean-cut lines; a simple, positive acting tailing mechanism; a hydraulic- or air-operated coil ejector which provides almost continuous coiling; easy regulation of the size of coil; and the cartridge type bearings which make possible roll removal without dismantling of the coiler. Feed rolls (not illustrated) can be provided, as well as coil nest side guides to stop "telescoping." All rolls are positively driven, with slipper type universal joints furnished on the larger machines.

Write for full information stating your approximate requirements.

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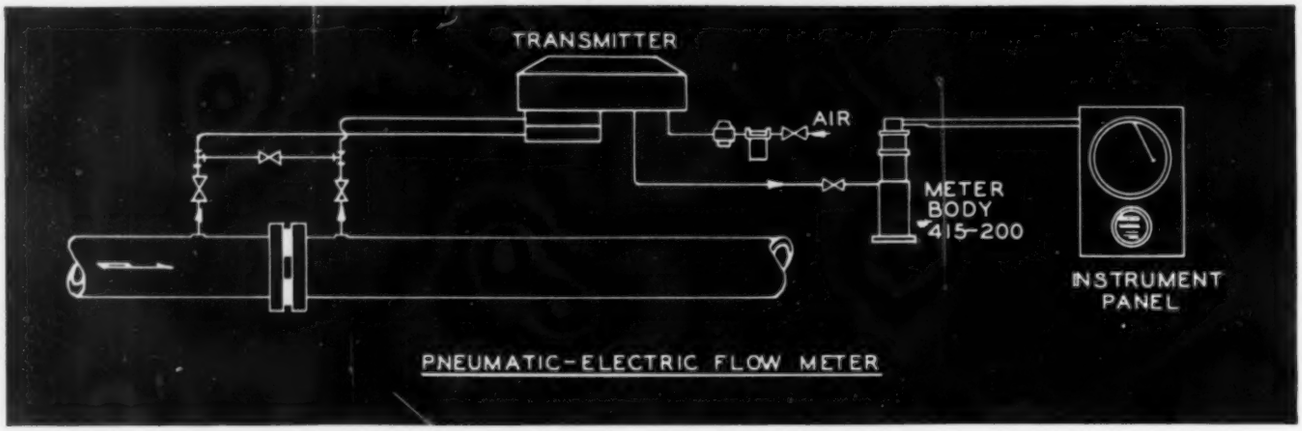

The Answer to Your **OXYGEN** *Metering Problems!*

Here is an oxygen flow metering system that will accurately integrate the rapidly fluctuating flows encountered in steel mill operations.

CONTINUOUS INTEGRATION

The electric integrator, operating on a modified watt hour principle, is continuous, not intermittent in operation — is extremely sensitive, acceleration and retardation being practically instantaneous. It will accurately integrate the most erratic fluctuations transmitted by the highly responsive meter element.

SENSITIVE METERING SYSTEM

The flow metering system, shown diagrammatically above, is a combination pneumatic-electric system for measuring a rapidly fluctuating flow. It consists of a pneumatic transmitter, an electric meter body and any desired combination of remote reading instruments. It has been especially designed to overcome the problems encountered in oxygen flow measurement.

Republic Continuous Integrator

FIELD TESTS

Laboratory tests of the complete meter have shown an over-all accuracy within ±2% for various flow cycles, including a cycle as short as 8 seconds "on" and 8 seconds "off". Field installations checked against weighed quantity of oxygen actually delivered over six month period substantiate these laboratory tests.

WIDE RANGE

For those installations where wide ranges of flow are encountered, a Republic pneumatic-electric metering system can be installed with a range of approximately 10 to 1. By a special piping arrangement, the range of accurate flow measurement can be extended to approximately 50 to 1.

The Republic pneumatic-electric flow metering system is completely described in Bulletin No. 48-2.

Write for your copy today.

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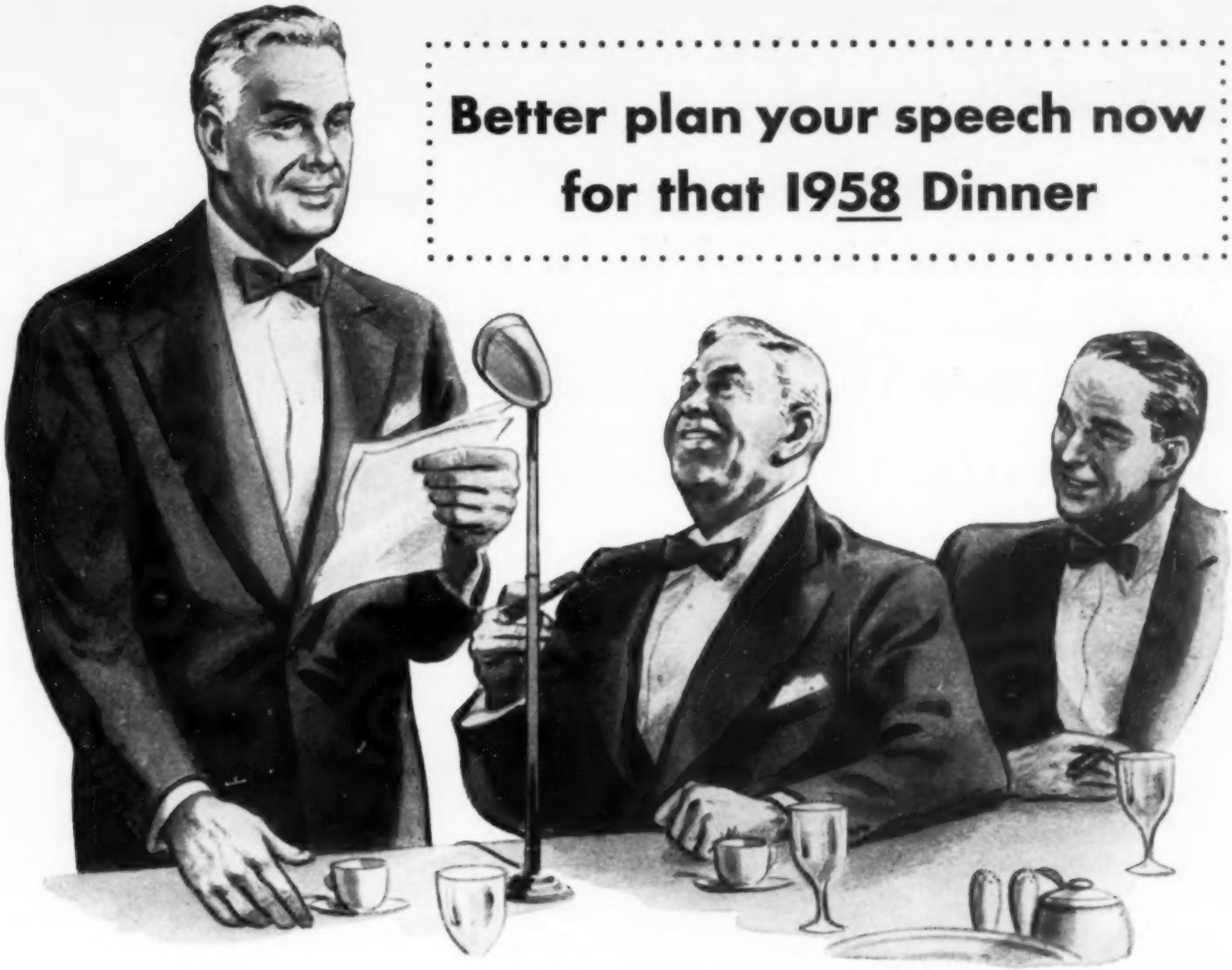
2240 Diversey Parkway, Chicago 47, Illinois



Better plan your speech now for that 1958 Dinner

Ten years can be a mighty short span in the history of a business. *Yours* for example.

When the time comes to address your fellow executives at the "Annual Banquet" in 1958, will there be a decade of outstanding company progress for you to review?

One way to make sure of a prospering business tomorrow is to make certain *today* that your employees are buying U.S. Security Bonds regularly—on the Payroll Savings Plan. The Payroll Savings Plan is a "look-ahead" plan for both management and employees. It builds up an employee group with a sense of extra security...with a tangible stake in the nation's future...a group bound to shun dollar-destroying philosophies. At maturity, the Bonds pay $4 for every $3 invested.

P.S.P. is paying off *today*, for every Security Bond dollar built up in the Treasury retires a dollar of the national debt that is potentially inflationary. Records of the companies that actively maintain the Payroll Savings Plan show improved employee attitudes. Absenteeism and accidents have dropped as the individual's feeling of security grows with regular Bond buying.

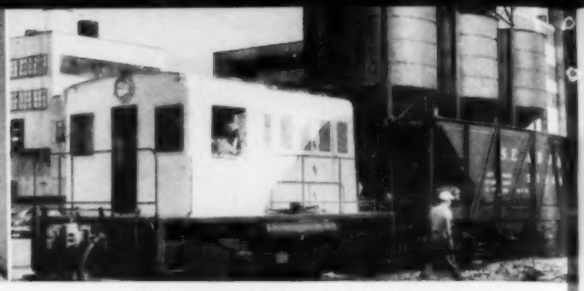
The whole plan of action for use within your company has been mapped out. Just call your Treasury Department's State Director, Savings Bond Division.

The Treasury Department acknowledges with appreciation the publication of this message by

IRON AND STEEL ENGINEER

This is an official U.S. Treasury advertisement prepared under the auspices of the Treasury Department and the Advertising Council.

Whitcomb 50-ton Diesel locomotive hauls phosphate onto wet storage tressel for dumping at International's Mulberry, Florida drying plant.



Whitcomb 35-ton Diesel locomotive switching at International's new Noralyn mine.

New NORALYN phosphate mine, worlds largest, picks WHITCOMB DIESELS for 24 HOUR duty

The handling of 1,500,000 annual tons of phosphate, 400 cars per day, takes a lot of switching and hauling. And here, WHITCOMB Diesel locomotives play an *important* role in the operation of Noralyn Mine, International Minerals and Chemical Corporation's new nine million dollar phosphate mine near Bartow, Florida. Operating on a *24-hour-basis,* these economical, powerful, durable WHITCOMB Diesels perform three separate switching operations: From mine to carrier, from carrier to the Mulberry drying plant, then back again onto carrier tracks for shipment to consumers.

Throughout industry, from phosphate mining, to metal working, to oil, to lumber, you'll find WHITCOMB Diesel locomotives playing a star role in modern, progressive, profitable production. Whatever your industry, whatever your size, it will pay you to learn why so many *important* companies pick WHITCOMB locomotives for *important* jobs.

WHITCOMB Diesel electric and Diesel mechanical locomotives are available up to 95 tons.

Whitcomb Diesel locomotives operate on a 24-hour basis, handle up to 400 cars per day in three separate switching operations.

There's no power cheaper than Diesel; no locomotive finer than a Whitcomb.

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News Supplement

(Continued from page 133)

Book Reviews

▲ The 1948 publication, A.S.T.M. Standards on Copper and Copper Alloys, includes the 106 standard specifications, test methods, definitions of terms, etc., covering copper and copper-base alloy products, which were developed by Committee B-5 on Copper and Copper Alloys and other A.S.T.M. technical committees.

Copies of this 516-page book, heavy paper cover, can be obtained from A.S.T.M. Headquarters, 1916 Race Street, Philadelphia 3, Pennsylvania, at $4.35 per copy; cloth binding, $5.00.

▲ Just released by the National Electrical Manufacturers Association, 155 East 44th Street, New York 17, are the following standards:

1. NEMA Standards for Shaft Couplings — The American Standard Integrally Forged Flange-type Shaft Couplings for Hydroelectric Units, B49.1–1947 has been adopted as a NEMA Standard. 12 pages, $0.45.

2. EEI-NEMA Report on Single-Phase Motor Starting Current Rules, NEMA Publication No. 116 — The object of this report is to specify limits for motor starting currents so that excessive voltage dips in the circuit, with resultant lighting will be prevented. Three recommended rules state the allowable locked-rotor amperes at rated voltage, without designating power factor. The report also contains a discussion of the single-phase motor starting problem and outlines typical applications of the rules. 8 pages, $0.25.

3. NEMA Definitions for Marine-Propulsion Gas Turbines Publication No. 48-134 — These standard definitions were compiled to furnish a common language for marine-propulsion gas turbines, and cover (1) gas turbine power plant and its components, (2) cycles and arrangements and (3) power plant performance. 12 pages, $1.25.

4. NEMA Standards for Transformers, Publication No. 48-132 — The transformer section of NEMA announces the issuing of Publication No. 48-132 covering the up-to-date standards for power and distribution transformers. The material in the EEI-NEMA fourth report on distribution transformers has been included in these standards, as well as the latest standards on power transformers. The ASA Transformer Subcommittee is actively working on additional standards for power transformers and, when these are completed, they will be incorporated in the NEMA Standards. Publication No. 48-132 gives valuable information for those responsible for the specifying and purchasing of transformers. Most of these standards have been incorporated in transformers now being built and the balance will be incorporated shortly. By closely cooperating with transformer users, these standards include the requirements of a majority of the users and permit the manufacturers to build a larger number of standard units. The manufacturing economies obtained have been passed on to the users, showing that the time and effort spent in preparing the standards has been to the mutual advantage of the users and the manufacturers. 104 pages, $4.00.

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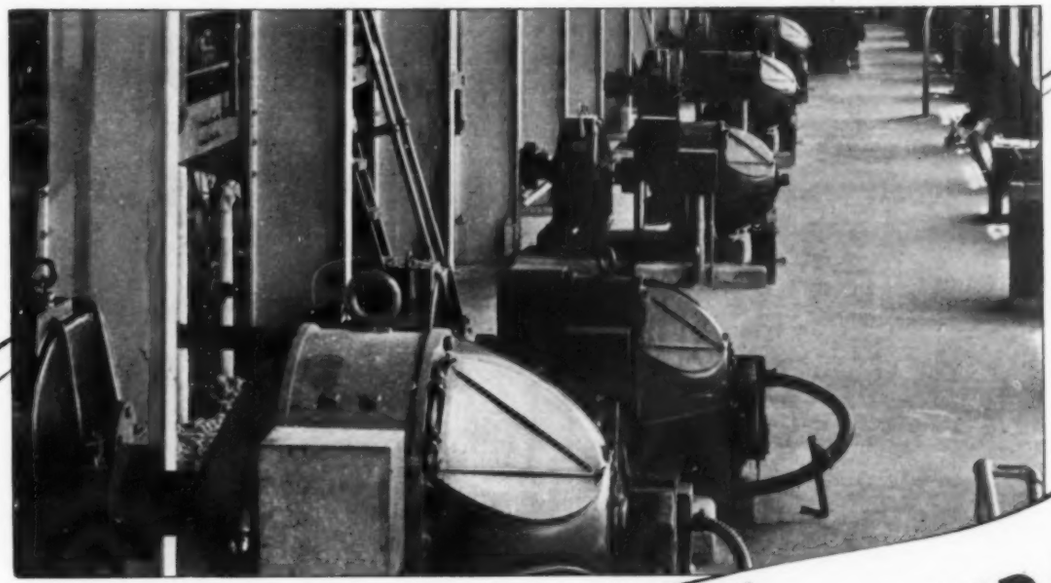

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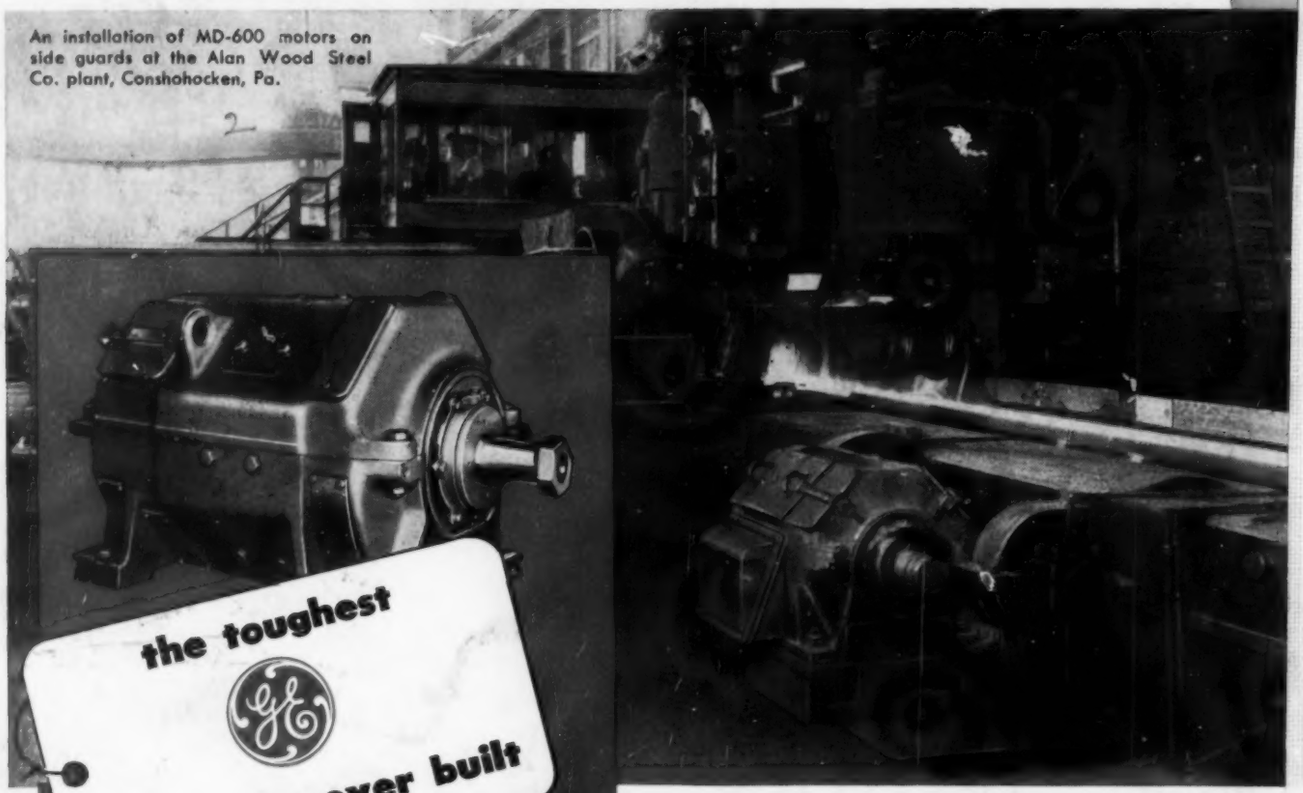

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(Required by the Acts of Congress of August 24, 1912, March 3, 1933 and July 2, 1946)

Name of Publication: *Iron and Steel Engineer*, published monthly at Pittsburgh, Pennsylvania. (Report of October 1, 1948.)

State of Pennsylvania
County of Allegheny

Before me, a notary public in and for the State and county aforesaid, personally appeared T. J. Ess, who, having been duly sworn according to law, deposes and says that he is the editor of the *Iron and Steel Engineer* and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Acts of March 3, 1933 and July 2, 1946, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

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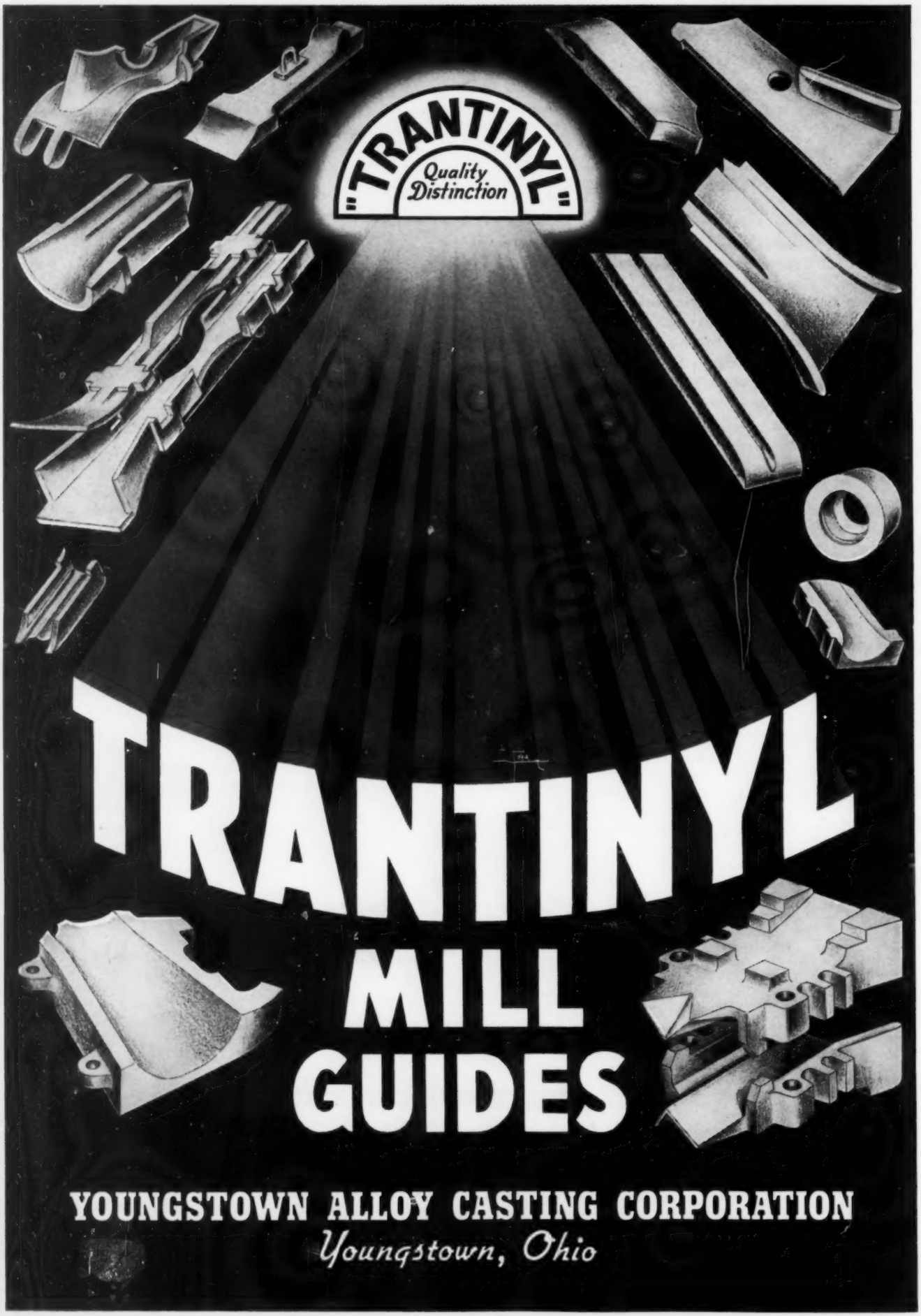
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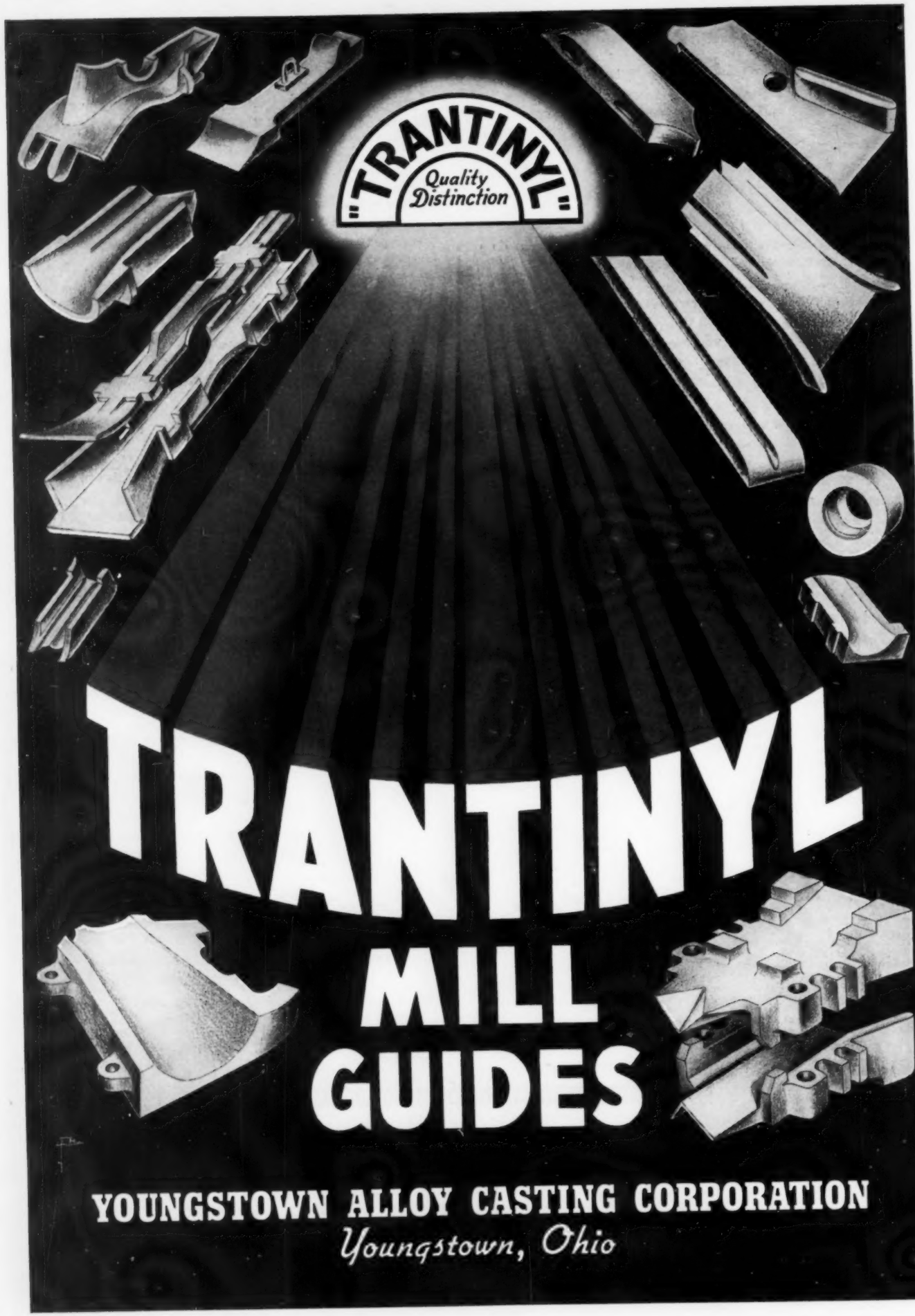
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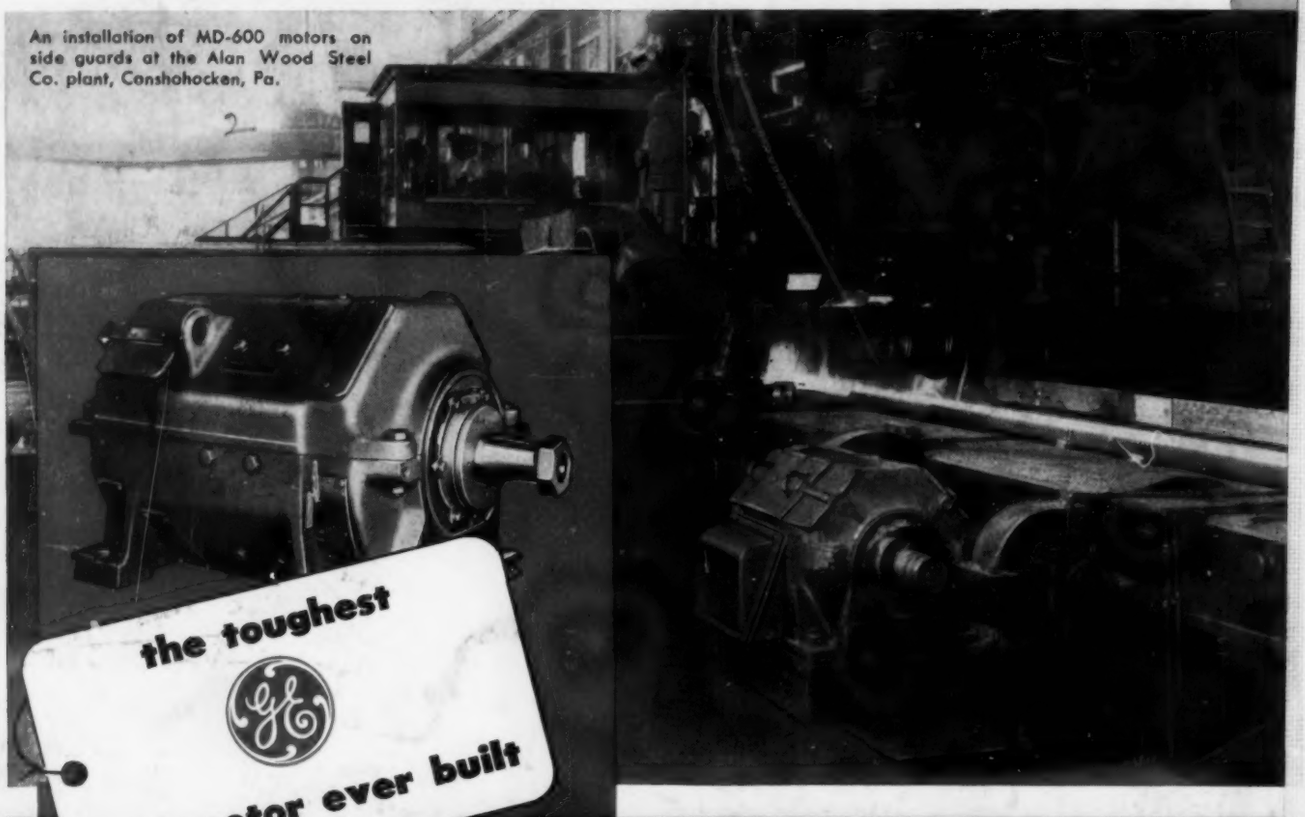

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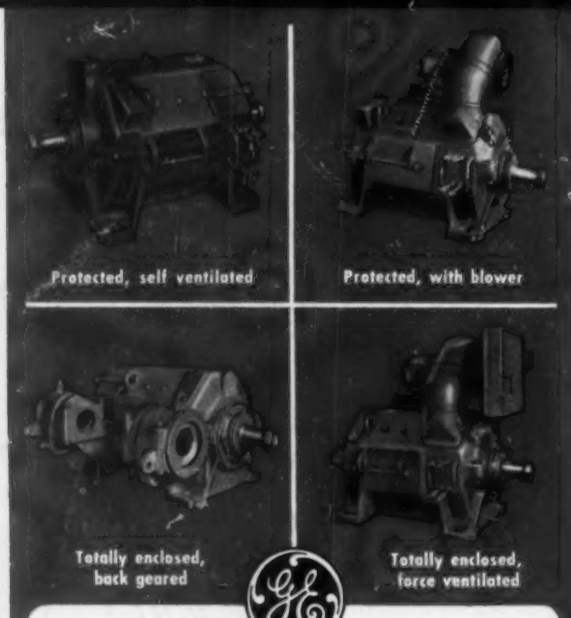

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